# CENTRAL ELECTRIC LIGHT AND POWER STATIONS.

By EDMOND E. LINCOLN, *Expert Special Agent.*

## CHAPTER I.—INTRODUCTION AND GENERAL EXPLANATION.

*Classes of stations included.*—For the purpose of this census a "central electric light and power station" means an electrical establishment operated as a unit, which distributes current to public or private customers for light, power, heat, or traction uses. Accordingly, in this report are included the statistics of all electric plants in the continental United States doing a public service business—that is, all plants, whether owned by individuals, firms, corporations, or municipalities, which generate or purchase electric current for sale, and which were in operation during any portion of the year ending December 31, 1917. All municipal plants, also, are included which do not actually sell current but which supply electrical energy for street or park lighting, as well as for public buildings and other public uses. In the case of electric street railways which sell current for light or power, whenever it was possible to secure separate reports for this portion of their business such central station statistics have been included.

*Classes of stations omitted.*—The large group of so-called isolated plants operated solely for the benefit of the owner in connection with the factories, mines, mills, stores, hotels, amusement parks, institutions of learning, etc., has been, as usual, excluded, even though, as sometimes happens, a small amount of current is sold to employees. Such plants are by no means typical of the electrical industry. Yet there are thousands of these plants, perhaps even a hundred thousand, some of which are of great size.

Further, no report has been secured from those plants owned and operated by the Federal or state governments primarily for the purpose of supplying light or power to public buildings, military posts, naval stations, Indian reservations, etc. The hydroelectric plants operated by the United States Reclamation Service, and in many cases selling a large part of their current to private consumers, have also been omitted. Finally, those plants which were idle throughout the year or were in process of construction at the end of the year have been excluded.

*Number of central electric stations.*—The number of central electric stations reported, 6,542, is by no means identical with the number of separate generating stations. Frequently one company, reporting as a unit, will have a number of generating stations in different localities which send current over high-tension lines to some central point of distribution. This is particularly true of the hydroelectric companies. Further, there have been instances when a holding company has made only one schedule return for several plants operated by it as separate units. When, however, an electric station generates and distributes current directly to consumers every effort has been made to ascertain this fact and to record it as a separate plant for the purposes of this census, irrespective of the owner or management. The number of separate localities actually served, it should be observed, is far greater than the number of central stations.

Again, in a number of instances, as previously mentioned, an electric light and power business is done by electric railways. Unless, however, separate reports could be secured for the central station portion of this business, such plants have not been tabulated with the central electric light and power stations.

Finally, from year to year new stations are constructed and combined with each other or with plants which reported for the preceding census. Many plants, formerly generating current, sell out to other concerns; their equipment is scrapped or kept idle, while they lose their identity and become merely distributing stations for larger systems. As a result of this constant combination and merging, the number of plants reported for the various census years can not, with complete accuracy, indicate the changes which have taken place. They do, however, show the general development of the industry.

*Period covered by census.*—The data incorporated in this report as a rule cover the calendar year 1917. In several cases, however, schedules were accepted for a fiscal year ending late in 1917 or early in 1918, when it would not seem practicable otherwise to obtain accurate figures. Statistics have also been included for those few plants which operated for only a portion of the year. Of these plants there are several classes—those new plants which began operation some time during the calendar year, those plants which temporarily ceased operation as a result of accidents, those which became defunct, and those which were succeeded by other plants. In case of the latter, combined schedules were prepared, showing the actual operations for the entire year.

*Classification of plants.*—In this report plants are classified in a number of ways for the purpose of statistical analyses.

1. The grouping into commercial and municipal stations is the most common and probably of greatest interest to the public. Commercial stations are those owned and operated by individuals, partnerships, or public service corporations, as distinguished from plants operated by municipalities. As municipal plants have gradually increased the scope and amount of their commercial business, and since comparatively few still confine their activities solely to the streets and public buildings, there may be a logical inconsistency in classifying plants as "commercial" and "municipal"; but, for the sake of uniformity, the terms are retained. The chief differences between the statistics for commercial and municipal plants at present arise more from the nature of ownership than from the general character of business done. It is interesting to note that municipal plants rarely pay taxes and issue no capital stock.

2. Central stations are further classified as "generating" and "purchasing." Generating stations are those which generate a part or all of their current, whether by means of steam, gas, oil, or water power. Purchasing plants are those which purchase all the current which they distribute, even though they may still have generating equipment not in use. The investment in this group of plants is normally very much smaller in proportion to the amount of business done, and their statistics are in general far simpler than for the other group.

3. Hydroelectric plants are generally referred to as those which generate electric current largely by means of water power, as contrasted with those plants which use other sources of primary power. For the purpose of future analyses, certain restrictions and qualifications of this definition will be made in the proper place. In view of the fact that these plants use no fuel and frequently invest huge sums in water-power development at a more or less advanced stage, and usually transmit their current long distances over high-tension lines, they clearly stand in a class by themselves.

4. Finally, central electric stations are classified as "purely electric" and "composite." The purely electric stations comprise only those engaged solely in the generation and sale of electrical energy. The composite stations include those operated by companies or municipalities which carry on other industries in connection with electric service, such as the manufacture of gas, the operation of waterworks, electric railways, ice plants, and other commercial enterprises. In numerous cases the companies have but one system of accounts, rendering it impracticable to obtain exact statistics covering the operation of the central electric stations. When this outside industry was merely incident to the operation of the electrical plant, the report was accepted with or without statistics covering such business, in accordance with the methods of accounting followed by the company in question. On the other hand, when an undertaking of considerable importance was carried on along with the electrical business, careful estimates were obtained, so that the statistics would represent only the operations of the electric stations. In a few instances of this kind, however, in which it was found to be impossible satisfactorily to segregate the items on the balance sheet, this inquiry on the schedule unavoidably covers both the electrical and other business.

When income was reported for steam heating, usually from surplus steam, no attempt was made to separate this business from that of the electric station work. Since the sale of electrical supplies and the wiring of buildings, etc., are customary functions of many companies, the income from such sources has been included, and invariably reported as income from "all other sources." Such plants, however, are not regarded as "composite."

*Free service.*—In most cases no cash income is received by municipal plants for electrical energy supplied for lighting streets and public buildings. In order, however, that the income shown in this report might be accurately compared with the total consumption of electrical energy for all stations, the schedule required that the income for service of this character furnished by municipal plants should be estimated on the basis of what would have been charged for similar service by commercial companies in near-by localities. Commercial plants, also, sometimes rendered free service in consideration of franchise or other privilege, for advertising purposes, or out of a sense of public duty, and a fair income for this service was estimated as above and included in the total.

*Comparison with previous censuses.*—A partial census of central electric stations was taken in connection with the census of manufactures of 1890. It was found possible, however, to canvass only the state of New York and the city of St. Louis. The results, therefore, are too incomplete for comparison with later periods. A further attempt was made in 1898 by the United States Commissioner of Labor to secure data regarding the electrical industry. The results, published in the Fourteenth Annual Report of the Commissioner, are of great interest and significance. Returns were secured from 320 of the 460 known municipal plants, and from only 632 of the 2,572 commercial plants then in existence.[1]

The first complete census of electric light and power stations, however, was taken in 1902, and comparative statistics are confined to that year and to the three quinquennial periods following. In general,

[1] Fourteenth Annual Report of United States Commissioner of Labor, p. 12.

the same form of schedule was used at these four censuses. For 1912, however, it was thought advisable to omit some of the less important subinquiries used at the earlier dates, as data secured from these inquiries were not entirely satisfactory. In that year, also, the amount of current purchased by the different plants was separated from the current generated. On the other hand, more detailed information was required regarding the financial statistics and operations of electric plants, with particular reference to the balance sheet. Deserving of further mention was the change in the method of securing the number of employees. In 1902 and 1907 the average number throughout the year was called for; but as it proved in many cases to be difficult to obtain correct averages, in 1912 the schedule required that the number employed on September 16 be returned, and in 1917 the date was fixed at September 29, or the nearest normal day. It is believed greater uniformity has been secured by the method pursued in 1912 and 1917.

Attention should be called specifically to a number of important changes and additions provided for in the 1917 schedule.

1. In reporting the number and capacity of dynamos, a distinction was made between those operated by water power and those operated by other power.

2. The important inquiry regarding the station output for the first time called for the quantities of current sold or used for the various kinds of service—electric light, power, other public service corporations—for the current used by the plant itself and the distribution and line losses, in addition to the amount generated and purchased.

3. For this census the number of lamps in public buildings and the number of commercial or private lamps were not required, as the accuracy of such data is open to serious question.

4. Under "revenues" the attempt was made for the first time to secure separate data regarding the income from the light and power business.

5. A number of changes were made in the balance sheet of the schedule in accordance with the system of accounting followed by the National Electric Light Association and the Interstate Commerce Commission, with a view to securing greater uniformity and avoiding errors in the returns. Specifically, the "value of plant and equipment" was called for instead of the "cost of construction, equipment, and real estate," as the latter was subject to possible misinterpretation. There was added an item for "other physical property," under which to report the value of investments of this character not properly included under "plant and equipment." Further, the value of "materials and supplies" was separated from "cash, notes, and accounts receivable." "Interest, dividends, and rents receivable," as well as the "premium on capital stock and funded debt," was also called for.

6. The schedule for this year also called for the kind and quantity of fuel used by central electric stations, as is the practice in the census of manufactures.

7. Again, the estimated population of the areas served with electric current was requested for 1917.

8. By means of correspondence and supplementary instructions, the number of separate generating stations, as contrasted with the total number of central electric stations reporting, was secured; and the number of different places served by all plants, which is far in excess of the actual number of stations, was ascertained.

*Chief difficulties encountered.*—It may at this point not be amiss to call attention to some of the chief difficulties encountered in collecting the statistics for this census. As the detailed answers required regarding the output of current appeared on the schedule for the first time, many of the smaller stations whose records are unsatisfactory, or which keep no records at all, found difficulty in supplying the data. Consequently, this inquiry, the answers to which are of the greatest importance, beyond a doubt necessitated far more attention by the office and more work on the part of special agents than any other portion of the schedule.

Following this, the balance sheet probably occasioned great difficulty, for, in spite of all that has been done by the National Electric Light Association, by the state public service commissions, and by the Federal Government through the Interstate Commerce Commission, many of the smaller plants do not yet keep their accounts according to any standard method. This is particularly true of the numerous group of municipal plants, many of which have not for any length of time been required to report to state commissions and which have not been forced to standardize their systems of accounts through central control. Hence for many of this group of plants a doubt remains regarding the accuracy of the figures given for the "value of plant and equipment," as well as regarding the reported "cash investment" and "profit and loss surplus." The nature of possible errors in this connection will be analyzed in the body of the report.

It was also a problem to secure the desired separation of revenues from light and power sales. With patience, however, the segregation of income was made in practically all cases, so that the current reported as sold for light and power can be fairly compared with the income from the same.

Finally, a few of the larger stations, from the nature of their business, were unable to return the number or horsepower of their stationary motors served. Hence the data presented under this head are not wholly complete.

Certain other difficulties and anomalies will be pointed out in the proper place; but no effort has been

spared, through detailed correspondence, through the field work of special agents, and through the judicious use of all available records, to make this census as comprehensive and accurate as possible.

*Special features of the report.*—Along with the numerous additions in material and changes in presentation, mention should also be made of certain *special tabulations* prepared for this report with a view to making it possible to study, in somewhat greater detail, important aspects of the efficiency of commercial and municipal plants.

1. The relative amounts of current generated and purchased by the two groups of plants, commercial and municipal, are shown.

2. Commercial and municipal stations have been grouped according to the population of the districts which they served, with a view to showing the density of service for both light and power.

3. By means of a carefully selected group of plants, the relative investments in electric stations per kilowatt capacity of dynamos are presented for plants classified according to size, for commercial and municipal plants, and for steam and hydroelectric plants, as well as for plants which use gas or oil.

4. Through the same process of selection and grouping of plants generating current by means of steam, water power, and gas or oil the relative financial and physical efficiency of operation is shown. For this purpose plants are grouped according to the quantity of current which they generate and according to their ownership, whether commercial or municipal.

5. Finally, an effort is made, in several of the more important points, to compare those plants which purchase all their current with the generating plants. More particularly, typical plants which generate no current have been grouped according to the amount of their output, so that the relative efficiency of size and ownership can be studied.

*Geographic divisions.*—In a number of the tables in this report the statistics are presented by geographic divisions. In most of the tables the states are grouped into nine grand divisions, but in a few of the tables it was necessary to present the totals by the five divisions used in 1907, in order that the figures might be comparable with those for prior censuses.

From Map 1 (p. 19) and the following list of states, by geographic divisions, the states in each division can readily be determined, whether the division grouping be that adopted for 1912 and 1917 or that used in 1907.

NORTH ATLANTIC DIVISION.

*New England:*
- Maine.
- New Hampshire.
- Vermont.
- Massachusetts.
- Rhode Island.
- Connecticut.

*Middle Atlantic:*
- New York.
- New Jersey.
- Pennsylvania.

SOUTH ATLANTIC DIVISION.

- Delaware.
- Maryland.
- Dist. of Columbia.
- Virginia.
- West Virginia.
- North Carolina.
- South Carolina.
- Georgia.
- Florida.

NORTH CENTRAL DIVISION.

*East North Central:*
- Ohio.
- Indiana.
- Illinois.
- Michigan.
- Wisconsin.

*West North Central:*
- Minnesota.
- Iowa.
- Missouri.
- North Dakota.
- South Dakota.
- Nebraska.
- Kansas.

SOUTH CENTRAL DIVISION.

*East South Central:*
- Kentucky.
- Tennessee.
- Alabama.
- Mississippi.

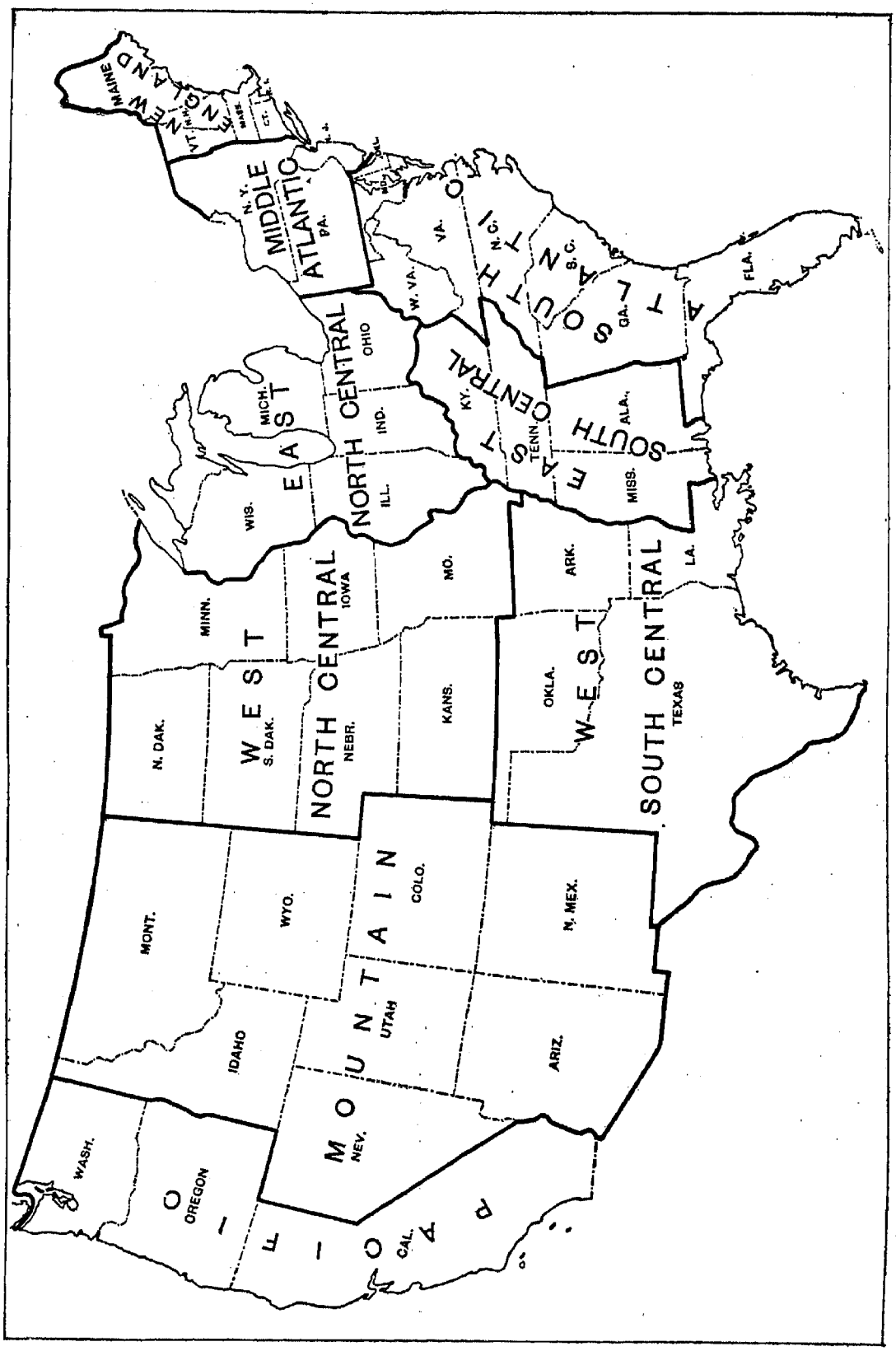
SOUTH CENTRAL DIVISION—contd.

*West South Central:*
- Arkansas.
- Louisiana.
- Oklahoma.
- Texas.

WESTERN DIVISION.

*Mountain:*
- Montana.
- Idaho.
- Wyoming.
- Colorado.
- New Mexico.
- Arizona.
- Utah.
- Nevada.

*Pacific:*
- Washington.
- Oregon.
- California.




MAP 1.—GEOGRAPHIC DIVISIONS AS DEFINED BY THE BUREAU OF THE CENSUS.

# CHAPTER II.—GENERAL DEVELOPMENT OF CENTRAL ELECTRIC LIGHT AND POWER STATIONS.

*Comparative summary of commercial and municipal plants: 1917.*—Before entering upon a detailed discussion of the various data secured for the present census, it will be of advantage to examine briefly the relative importance of commercial and municipal electric stations in the United States. Accordingly, in Table 5 are shown the items of most general interest for both groups of plants, together with the per cent which each forms of the total.

**Table 5**

COMPARATIVE SUMMARY OF COMMERCIAL AND MUNICIPAL CENTRAL ELECTRIC STATIONS: 1917.

| | Total. | Commercial. | Municipal. | Per cent of total. | |
|---|---|---|---|---|---|
| | | | | Commercial. | Municipal. |
| Number of plants | 6,542 | 4,224 | 2,318 | 64.6 | 35.4 |
| Generating all or part of current | 5,124 | 3,347 | 1,777 | 65.3 | 34.7 |
| Purchasing all current | 1,418 | 877 | 541 | 61.8 | 38.2 |
| Number of separate generating stations | 5,952 | 4,116 | 1,836 | 69.2 | 30.8 |
| Number of cities, towns, etc., served by all stations | 13,716 | 11,349 | 2,367 | 82.7 | 17.3 |
| Population of districts served with current | [1] 62,919,662 | 56,459,723 | 13,671,460 | 80.5 | 19.5 |
| Value of plant and equipment | $3,060,392,141 | $2,933,016,941 | $127,375,200 | 95.8 | 4.2 |
| Total income | $526,894,240 | $486,634,021 | $40,260,219 | 92.4 | 7.6 |
| Sale of current for light, heat, and power, including free service | $502,059,980 | $462,473,917 | $39,586,063 | 92.1 | 7.9 |
| All other sources | $24,834,260 | $24,160,104 | $674,156 | 97.3 | 2.7 |
| Total expenses, including salaries and wages [2] | $426,568,307 | $395,127,395 | $31,440,912 | 92.6 | 7.4 |
| Total number of persons employed | 105,541 | 94,679 | 10,862 | 89.7 | 10.3 |
| Prime movers: | | | | | |
| Number of units | 13,795 | 10,387 | 3,408 | 75.3 | 24.7 |
| Total horsepower | 12,936,755 | 12,077,657 | 859,098 | 93.4 | 6.6 |
| Dynamos: | | | | | |
| Number | 13,428 | 9,991 | 3,437 | 74.4 | 25.6 |
| Kilowatt capacity | 8,994,407 | 8,411,944 | 582,463 | 93.5 | 6.5 |
| Output of stations (total) | 31,044,049,234 | 29,812,190,746 | 1,231,858,488 | 96.0 | 4.0 |
| Kilowatt hours generated | 25,438,303,272 | 24,398,983,183 | 1,039,320,089 | 95.9 | 4.1 |
| Kilowatt hours purchased | 5,605,745,962 | 5,413,207,563 | 192,538,399 | 96.6 | 3.4 |
| Kilowatt hours sold (total) [3] | 25,751,964,800 | 24,722,517,379 | 1,029,447,421 | 96.0 | 4.0 |
| For light | 5,112,516,949 | 4,445,217,785 | 667,299,164 | 86.9 | 13.1 |
| For power | 13,174,827,277 | 12,833,191,106 | 341,636,171 | 97.4 | 2.6 |
| To other public service corporations | 7,464,620,574 | 7,444,108,488 | 20,512,086 | 99.7 | 0.3 |
| Number of street lamps: | | | | | |
| Arc | 256,950 | 206,957 | 49,993 | 80.5 | 19.5 |
| Incandescent and other varieties | 1,392,284 | 969,709 | 422,575 | 69.6 | 30.4 |
| Stationary motors served: | | | | | |
| Number [4] | 555,924 | 504,864 | 51,060 | 90.8 | 9.2 |
| Horsepower capacity | 9,216,330 | 8,790,707 | 425,623 | 95.4 | 4.6 |
| Number of meters | 7,102,569 | 6,172,436 | 930,133 | 86.9 | 13.1 |
| Number of customers | 7,178,703 | 6,202,189 | 976,514 | 86.4 | 13.6 |

[1] Duplicated population eliminated.
[2] In addition to salaries and wages, includes the cost of supplies and materials used for ordinary repairs and replacements, advertising, fuel, mechanical power, electrical energy purchased, taxes, charges for depreciation and charges for sinking fund, and all other expenses incident to operation and maintenance.
[3] Resales not deducted.
[4] Figures not complete for commercial plants.

The number of municipal plants is 35.4 per cent of the total for all plants in the United States, but in no other item is so high a percentage shown. It also appears that the number of municipal plants generating all or part of their current is relatively smaller (34.7 per cent) than the number purchasing all current (38.2 per cent). It must be explained, however, that there are a number of plants in either group which have generating equipment, but did not during the year produce any current. Hence the number of central electric stations reported as purchasing all current is not identical with the number having no generating equipment. It is also interesting to note that commercial plants frequently report on the same schedule a number of separate generating stations which are operated as part of the single system. Establishments generating all or part of their current will always be somewhat smaller in this group than the number of separate generating stations, as is indicated by the figures in the table. For municipal plants, on the other hand, the number of separate generating stations is practically identical with the number of establishments reporting.

In this connection it is of great significance to find that commercial plants, while representing only 64.6 per cent of the total number, serve 82.7 per cent of all municipalities furnished with electric current. This is due to the fact that most commercial stations distribute current directly to consumers throughout an extensive territory, some supplying scores of separate localities, while almost without exception municipal plants serve only the municipalities in which they are located. On the other hand, it must not be forgotten that frequently several commercial plants are located

in the same city, one usually doing a general light and power business, while the others may incidentally do a little lighting, but will in the main supply current only for power or to other companies. There were 405 cases of this kind in 1917. A comparison of the number of commercial plants (4,224) with the number of places served by the same (11,349) discloses the fact that the average plant in this group supplies current in nearly 3 different places. The greatest average number of localities served by single stations is to be found in California, where hydroelectric development is most extensive, and the average plant serves about 9 separate localities. In Pennsylvania, also, a high average of more than 5 localities per plant is found, in New Jersey the average is about 8, and in Rhode Island almost 10, though the actual number of plants is very small (8). Finally, it is interesting to note that, without deducting duplications, commercial plants supply 80.5 per cent of the aggregate population of all districts served with electric current. In making such a comparison, however, it should be remembered that an appreciable number of the larger municipal plants (190) are operating in territory already served by commercial stations, and frequently do only a street lighting business. Hence the relative amount of population actually served would not be so great as the figures given would seem to indicate (19.5 per cent).

So far as the value of plant and equipment is concerned, it is obvious that municipal plants are relatively of slight importance, reporting only 4.2 per cent of the total. In "total income" their position is slightly better, or 7.6 per cent of the total for both groups. They report only 6.6 per cent of the total horsepower of prime movers and only 6.5 per cent of the kilowatt capacity of dynamos, while they generate only 4.1 per cent of all current. Further, it appears that practically all of the output of municipal plants is sold for lighting purposes (13.1 per cent of the total sold for light by both groups) rather than for power or to other public service corporations. The relative number of customers supplied by municipal plants is 13.6 per cent of the total, though it is apparent that the amount of current sold per customer is far lower than in the case of commercial plants. The average rates received by municipal plants for their current are much higher than those charged by the other group, as is indicated by the fact that, while they sell only 4 per cent of all current, they receive 7.9 per cent of the income from the sale of current. More detailed comparisons will be made in other portions of the report.

*Isolated electric stations.*—While no effort was made in this census to secure data regarding the number and importance of the so-called isolated electric plants—that is, those which do not distribute current to the public, but are operated solely for the owners' use, usually in connection with manufacturing establishments—yet it may be of public interest to indicate the probable scope of this phase of the electric industry. According to the census of manufactures for 1914 there were in that year 205,590 industrial establishments, or 74.5 per cent of the total, which reported the use of mechanical power of different kinds.[1] The total primary horsepower reported, both owned and rented, was 22,547,574, which, of course, comprises all power which is "primary" from the standpoint of the manufacturing establishments using it. Of this amount, 4,929,967, or 21.9 per cent, consisted of motor horsepower operated by establishments generating their own electric current. This amount of power, represented by 320,260 motors, may be profitably compared with the 435,473 motors, with a total horsepower of 4,130,619, reported by central electric light and power stations in 1912. The number of motors served by the latter, while having a total horsepower 16.2 per cent less than that electrically operated by the manufacturing establishments, was 36 per cent greater. In other words, the average horsepower per motor served was, for central electric stations, 9.5 per cent, and for manufacturing establishments generating their own current, 15.4. Though exact figures are not at present available, yet if it be assumed that the establishments reporting 4,929,967 electrical horsepower owned also represent 21.9 per cent of all establishments using mechanical power, according to this computation there would have been in 1914 about 45,000 isolated plants in the United States operated solely in connection with industrial enterprises. To these, as indicated in Chapter I, there should be added a large but indeterminate number of isolated plants operated by mines, stores, hotels, pleasure resorts, public buildings, and institutions of various sorts, such as schools, colleges, prisons, etc.

*Central station work of electric railways.*—A number of electric railway companies have, at the different census periods, been engaged in the sale of electric current for light and power. Some of these conduct their central station work as a special department and are therefore able to submit satisfactory schedules for census purposes. The reports from such companies have, of course, been included with those for central stations and they are regarded as composite plants. In 1917, however, there were 160 electric street railway companies which, while doing an extensive electric light and power business, did not keep their accounts in such a way as to be able to furnish complete data to the Census Bureau. Accordingly, in Table 6 a brief separate tabulation has been made of the income of the electric light and power departments of such railway companies.

[1] Abstract of the Census of Manufactures for 1914, pp. 491–493.

**Table 6** — ELECTRIC LIGHT AND POWER DEPARTMENTS OF ELECTRIC RAILWAY COMPANIES.

| | 1917 | 1912 | 1907 | Per cent of increase:[1] 1907–1917. |
|---|---|---|---|---|
| Number of stations | 160 | 169 | 177 | −9.6 |
| Gross income | $54,348,875 | $31,515,582 | $17,291,824 | 214.3 |
| Electric service | [2]$52,919,886 | [2]$30,984,555 | $16,576,555 | 219.2 |
| All other sources | $1,428,989 | $531,027 | $715,269 | 99.8 |
| Stationary motors: | | | | |
| Number | [3] | [3] | 20,468 | ..... |
| Horsepower | [3] | [3] | 158,923 | ..... |
| Meters on consumption circuits, number | [3] | [3] | 213,886 | ..... |

[1] A minus sign (−) denotes decrease.
[2] Exclusive of the estimated value of free service, amounting to $42,734 in 1917 and $66,051 in 1912.
[3] Not reported.

From the table it appears that, while there has not been much change in the number of the electric light departments of street railway companies since 1907, there has been a very marked increase in their income from electric service. This income has increased during the decade 219.2 per cent, as opposed to an increase of only 196 per cent for all central electric stations in the United States. At the present time these 160 stations, which comprise only 2.4 per cent of all central electric stations in the United States, report an income of $52,919,886 from the sale of electric current only, as compared with a central station income from the same source of $502,059,980. In other words, they report an income equal to 10.5 per cent of that of the central stations. It is further interesting to find that the average total income of this group is $339,680, as opposed to an average of only $80,540 for central electric stations. The estimated value of free service furnished by these electric light and power departments amounted to $42,734 in 1917, and, in addition, there were more than 200 street railway companies without any light and power departments which report an income from the sale of current amounting to $6,710,099. This current was sold in part to other electric railway companies, as well as to central electric stations, and to consumers direct for light and power. Accordingly, the total income derived from the sale of electric current by street railways and not included in the income of central stations, including the value of free service, is $59,672,719, or 10.2 per cent of the central station income. To this should also be added the income of $1,428,989 from "all other sources," making a total of $61,101,708.

*Comparison of central electric stations and gas plants.*—Table 7 shows for the most nearly comparable periods the relative importance of central electric stations and gas plants during the past census decade.

**Table 7** — COMPARATIVE SUMMARY—CENTRAL ELECTRIC STATIONS AND GAS PLANTS.

| | General electric stations. | | | Gas plants. | | | Per cent of increase.[1] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Central electric stations. | | | Gas plants. | | |
| | 1917 | 1912 | 1907 | 1914 | 1909 | 1904 | 1907–1917 | 1912–1917 | 1907–1912 | 1904–1914 | 1909–1914 | 1904–1909 |
| Number of establishments | 6,542 | 5,221 | 4,714 | 1,284 | 1,296 | 1,019 | 38.8 | 25.3 | 10.8 | 26.0 | −0.9 | 27.2 |
| Value of plant and equipment | $3,060,392,141 | $2,175,678,266 | $1,096,913,622 | [2]$1,252,421,584 | [2]$915,536,762 | [2]$725,035,204 | 179.0 | 40.7 | 98.3 | 72.7 | 36.8 | 26.3 |
| Gross income [3] | $526,894,240 | $302,273,398 | $175,642,338 | $220,237,790 | $166,814,371 | $125,144,945 | 200.0 | 74.3 | 72.1 | 76.0 | 32.0 | 33.3 |
| From sale of electric current or gas | $502,059,980 | $287,138,657 | $169,614,691 | $175,065,920 | $138,615,309 | $112,662,568 | 196.0 | 74.8 | 69.3 | 55.4 | 26.3 | 23.0 |
| From all other sources | $24,834,260 | $15,134,741 | $6,027,647 | $45,171,870 | $28,199,062 | $12,482,377 | 312.0 | 64.1 | 151.1 | 261.9 | 60.2 | 125.9 |
| Total number of persons employed | 105,541 | 79,335 | 47,632 | 63,915 | 50,730 | 39,972 | 121.6 | 33.0 | 66.6 | 59.9 | 26.0 | 26.9 |

[1] A minus sign (−) denotes decrease.
[2] Capital invested—owned and borrowed.
[3] Exclusive of the income reported by the electric light and power departments of electric railways, as follows: In 1917, $54,348,875; in 1912, $31,515,582; and in 1907, $17,291,824.

It will be observed that, while the rate of increase in investment during the latest five-year period has been about the same for electric light and power plants (40.7 per cent) as for gas plants (36.8 per cent), the rate of increase in gross income has been considerably more than twice as rapid for the former. On the other hand, there has not been much disparity between the two industries in the rate of increase of the total number of persons employed. The number of gas plants actually decreased slightly between 1909 and 1914, whereas there was an increase of 25.3 per cent between 1912 and 1917 in the number of electric stations, but during the preceding five-year period the former increased much more rapidly than the latter (27.2 as opposed to 10.8 per cent). During the decade the rate of increase in every item was much more rapid for electric stations than for gas plants, the increase in the income from the sale of electric current being more than three times as rapid as that from the sale of gas. Finally, during each period there has been, in practically every instance, a slight but certain decline in the relative proportion which the gas industry bears to the total for central electric stations and gas plants. The comparatively large amount of income derived from "all other sources" by gas plants is, of course, to be accounted for by the disposal of numerous by-products of this industry.

*Commercial and municipal stations combined.*—As indicated by Table 8, the growth in importance during

the last decade of the electric light and power industry has been far in excess of the increase in the number of separate plants. The actual numerical increase—1,321 between 1912 and 1917 and 507 between 1907 and 1912—is by no means identical with the number of new stations which have been installed, since many of the plants reporting at one census are in the meantime combined with other plants, while frequently even new stations are merged with others, new or old, before they have been established long enough to make the report for the census. It is, however, interesting to find that the number has increased much more rapidly (25.3 per cent) during the latest five-year period than during the preceding period 1907–1912, when the rate of increase was only 10.8 per cent. For both periods, also, the numerical increase has been considerably more rapid for municipal plants. Those important items which show the greatest increase for the decade are: "Value of plant and equipment" (179 per cent), "total income" (200 per cent), "expense" (217.9 per cent), "total horsepower of prime movers" (215.7 per cent), "kilowatt capacity of dynamos" (232 per cent), "kilowatt hours generated" (333.9 per cent), "number of customers" (268.7 per cent), and "horsepower of stationary motors served" (458.9 per cent).

**Table 8**

| | COMMERCIAL AND MUNICIPAL CENTRAL ELECTRIC STATIONS. | | | | | |
|---|---|---|---|---|---|---|
| | 1917 | 1912 | 1907 | Per cent of increase.[1] | | |
| | | | | 1907–1917 | 1912–1917 | 1907–1912 |
| Number of stations[2] | 6,542 | 5,221 | 4,714 | 38.8 | 25.3 | 10.8 |
| Commercial | 4,224 | 3,659 | 3,462 | 22.0 | 15.4 | 5.7 |
| Municipal | 2,318 | 1,562 | 1,252 | 85.1 | 48.4 | 24.8 |
| Value of plant and equipment | $3,060,392,141 | $2,175,678,266 | $1,096,913,622 | 179.0 | 40.7 | 98.3 |
| Total income[3] | $526,894,240 | $302,273,398 | $175,642,338 | 200.0 | 74.3 | 72.1 |
| Light, heat, and power, including free service | $502,059,980 | $287,138,657 | $169,614,691 | 196.0 | 74.8 | 69.3 |
| All other sources | $24,834,260 | $15,134,741 | $6,027,647 | 312.0 | 64.1 | 151.1 |
| Total expenses, including salaries and wages[4] | $426,508,307 | $234,577,277 | $134,196,911 | 217.9 | 81.8 | 74.8 |
| Total number of persons employed | 105,541 | 79,335 | 47,632 | 121.6 | 33.0 | 66.6 |
| Prime movers: | | | | | | |
| Number | 13,795 | 11,902 | 10,998 | 25.4 | 15.9 | 8.2 |
| Total horsepower | 12,936,755 | 7,530,044 | 4,098,188 | 215.7 | 71.8 | 83.7 |
| *Dynamos:* | | | | | | |
| Number | 13,428 | 12,610 | 12,173 | 10.3 | 6.5 | 3.6 |
| Kilowatt capacity | 8,994,407 | 5,165,439 | 2,709,225 | 232.0 | 74.1 | 90.7 |
| Output of stations: | | | | | | |
| Kilowatt hours generated | 25,438,303,272 | 11,569,109,885 | 5,862,276,737 | 333.9 | 119.9 | 97.3 |
| Kilowatt hours purchased | 5,605,745,962 | 2,613,502,605 | (5) | ..... | 114.5 | ..... |
| Number of street lamps: | | | | | | |
| Arc | 256,950 | 348,643 | (6) | ..... | −26.3 | ..... |
| Incandescent and other varieties | 1,392,284 | 681,957 | (6) | ..... | 104.2 | ..... |
| Stationary motors served: | | | | | | |
| Number[7] | 555,924 | 435,473 | 167,184 | 232.5 | 27.6 | 160.5 |
| Horsepower capacity | 9,216,330 | 4,130,619 | 1,649,026 | 458.9 | 123.1 | 150.5 |
| Number of customers | 7,178,703 | 3,837,518 | 1,946,979 | 268.7 | 87.1 | 97.1 |

[1] A minus sign (−) denotes decrease.
[2] The term "station" as here used may represent a single electric station or a number of stations operated under the same ownership.
[3] Exclusive of $59,629,985 in 1917, $36,500,030 in 1912, and $20,093,302 in 1907 reported by electric railway companies as income from sale of electric current for light or power or from sale of current to other public service corporations.
[4] In addition to salaries and wages, includes the cost of supplies and materials used for ordinary repairs and replacement, advertising, fuel, mechanical power, electrical energy purchased, taxes, charges for depreciation, and all other expenses incident to operation and maintenance.
[5] Not reported.
[6] Figures not available.
[7] In 1917, 41 stations failed to report the number of their motors.

To refer to certain items more specifically, it appears that there has been a marked falling off in the rate of increase in investment during the latest five-year period, from 98.3 per cent to only 40.7 per cent, though there has not been so much difference in the absolute increase. This condition is to be expected as the business becomes more widely established. Also, the abnormally high cost of materials and equipment of all kinds during the last two or three years of the period no doubt acted as a real check on capital expenditures. The rate of increase in the total income (74.3 and 72.1 per cent, respectively) has been almost identical during the two five-year periods, while total expenses have increased somewhat more rapidly (81.8 and 74.8 per cent, respectively). The number of employees increased only *half as rapidly (33 per cent)* between 1912 and 1917 as between 1907 and 1912. These figures would indicate a much greater efficiency of labor at the present time—a fact which is no doubt in the main accounted for by the development of larger scale productive units in the industry. While the total horsepower of prime movers and the kilowatt capacity of dynamos have at each period shown an increase commensurate with the growth in income, the total number of units in each case has remained almost unchanged, though there has been an actual decrease of considerable proportions in the number of steam engines and a marked increase in the number of internal-combustion engines. There has, further, been a gratifying increase in the amount of current generated, 119.9 per cent from 1912 to 1917, and 97.3 per cent from 1907 to 1912. As this increase has been much more rapid than the increase of income, it is evident that customers are progressively securing their light and power at lower rates. In this connection, also, the fact that the number of customers has been increasing far more rapidly (87.1 per cent in the later

*period and 97.1 per cent at the earlier date)* than the number of stations and the income from the sale of current no doubt suggests that more people are being reached directly from a given center of distribution and that the business per customer is less than formerly. Finally, while not much significance can be attached to the apparent rate of increase in the number of stationary motors served, because of the fact that some very important plants failed to make complete returns in 1917, yet the unusually marked increase in the capacity of these motors indicates the continually growing utilization of electrical power in industry.

*Commercial central electric stations.*—Table 9 shows for commercial stations taken separately the importance of the leading items secured for census purposes for the years 1917, 1912, and 1907, together with the per cent of increase in the different items.

**Table 9**

| | COMMERCIAL CENTRAL ELECTRIC STATIONS. | | | | | |
|---|---|---|---|---|---|---|
| | 1917 | 1912 | 1907 | Per cent of increase.[1] 1907–1917 | 1912–1917 | 1907–1912 |
| Number of stations | 4,224 | 3,659 | 3,462 | 22.0 | 15.4 | 5.7 |
| Value of plant and equipment | $2,933,016,941 | $2,098,613,122 | $1,054,034,175 | 178.3 | 39.8 | 99.1 |
| Total income | $486,634,021 | $279,054,409 | $161,630,339 | 201.1 | 74.4 | 72.6 |
| Light, heat, and power, including free service | $462,473,917 | $264,474,949 | $156,000,257 | 196.4 | 74.9 | 69.5 |
| All other sources | $24,160,104 | $14,579,460 | $5,630,082 | 329.1 | 65.7 | 159.0 |
| Total expenses, including salaries and wages [2] | $395,127,395 | $217,660,112 | $123,880,291 | 219.0 | 81.5 | 75.7 |
| Total number of persons employed | 94,679 | 71,395 | 42,066 | 125.1 | 32.6 | 69.7 |
| Prime movers: | | | | | | |
| Number | 10,387 | 9,326 | 8,981 | 15.6 | 11.4 | 3.8 |
| Total horsepower | 12,077,657 | 6,970,716 | 3,776,837 | 219.8 | 73.3 | 84.6 |
| Dynamos: | | | | | | |
| Number | 9,991 | 9,843 | 9,778 | 2.2 | 1.5 | 0.7 |
| Kilowatt capacity | 8,411,944 | 4,768,762 | 2,500,209 | 236.4 | 76.4 | 90.7 |
| Output of stations: | | | | | | |
| *Kilowatt hours generated* | 24,398,983,183 | 11,031,583,155 | 5,572,813,949 | 337.8 | 121.2 | 98.0 |
| Kilowatt hours purchased | 5,413,207,563 | 2,524,922,228 | [3] | ..... | 114.4 | ..... |
| Number of street lamps: | | | | | | |
| Arc | 206,957 | 264,152 | [4] | ..... | −21.7 | ..... |
| Incandescent and other varieties | 969,709 | 474,488 | [4] | ..... | 104.4 | ..... |
| Stationary motors served: | | | | | | |
| Number | 504,864 | 413,578 | 162,677 | 210.3 | 22.1 | 154.2 |
| Horsepower capacity | 8,790,707 | 3,966,328 | 1,617,337 | 443.5 | 121.6 | 145.2 |
| Number of customers | 6,202,189 | 3,311,870 | 1,663,354 | 272.9 | 87.3 | 99.1 |

[1] A minus sign (−) denotes decrease.
[2] In addition to salaries and wages, includes the cost of supplies and materials used for ordinary repairs and replacement, advertising, fuel, mechanical power, electrical energy purchased, taxes, charges for depreciation, and all other expenses incident to operation and maintenance.
[3] Not reported.
[4] Figures not available.

The numerical increases shown in the various periods—565 between 1912 and 1917 and 197 between 1907 and 1912—do not disclose to the casual student of the problem the actual conditions which exist so far as the number of commercial central electric stations are concerned. While figures are not available for 1912, a careful analysis of the schedules for 1917 reveals the fact that 1,593 plants, of which 1,568 were newly constructed and 25 had been transferred from municipal to commercial ownership, made returns at this date which did not report in 1912. It further appears that of the 1,028 commercial stations reporting in 1912 but not in 1917, 711 were combined with other commercial lighting plants, 9 with municipal plants, 8 with street railways, and 131 changed from commercial to municipal ownership, while the remaining 99 were not, so far as could be ascertained, operated in 1917, though it is probable that a large portion may have been absorbed by other plants. These figures are significant as showing the rapid growth in number of new commercial plants as well as the marked tendency toward combination in this industry. The number of stations constructed between 1912 and 1917 was 42.9 per cent of the total number reporting at the earlier date, and, had there been no combinations with other commercial companies of some kind, the net increase would have been at least 37 per cent. It is also interesting to note in this connection that 99 commercial plants do no general lighting business. Five of these furnish current only for street or park lighting, while the remaining 94 sell practically all of their current in bulk to other public service corporations and sometimes do a certain amount of power business. Finally, 877 plants, or 20.8 per cent of the total, as contrasted with 439 in 1912, generated no current during the year, though a few of them still retained their generating equipment.

The greatest number of commercial plants is to be found in the West North Central division, where the increase since 1912 has been 292, until at present there are 970 plants. The East North Central group follows, with 818 plants, while the Pacific division is at the bottom of the list, with 206. In the New England division there has been no change whatever in number, while the Middle Atlantic shows a decrease of 11 and the Pacific a decrease of 5. All other divisions have had increases ranging from 32 to 90

plants. Of the separate states, 4 have between 200 and 300 commercial plants, New York heading the list with 277, while Pennsylvania, Texas, and Missouri follow, with 232, 230, and 206, respectively. There are 11 other states which have between 100 and 200 plants. In 12 states, as a result of combinations, there has been an actual decrease in the number of plants to the extent of 18 in California and 9 in New Jersey and Colorado, with less marked decreases in the remaining. Ohio reports the same number at both periods. Finally, those states showing the greatest increase in number are Missouri (81), North Dakota (68), Nebraska (36), North Carolina (33), Minnesota (31), South Dakota (31), and Kentucky (30), most of which were not so well supplied relative to their population in 1912. There were, in 1917, 60 companies having their generating stations in one state and distributing a portion or all of their current in adjacent states. In a few of these cases it was necessary for the purposes of this census to regard that portion of the plant and equipment located in an adjoining state as if it were a separate plant. The only important instances of this sort were between West Virginia and Ohio and Oregon and Washington.

Probably little need be said regarding the increases in the various items shown for commercial stations separately, since, as indicated in Table 5, this group of plants does the bulk of the central station business in the United States. Hence, most of the explanations in connection with Table 8, covering both commercial and municipal plants in the United States, will also apply to the commercial plants alone. Perhaps, however, attention should be paid to the fact that during the decade the total number of dynamos has increased 2.2 per cent, while the kilowatt capacity has increased by 236.4 per cent, or more than one hundred times as rapidly. This fact, taken in connection with the 22 per cent growth in the number of stations, indicates that not only have increasingly large generating units been installed by the newer plants but also old equipment has been rapidly discarded. It is further significant that a similar tendency exists in connection with the primary power equipment, in which the increase in capacity has been 219.8 per cent between 1907 and 1917, while the increase in the number of units has been only 15.6 per cent. These figures, however, are not so striking as in the case of statistics relating to the dynamos. Finally, the number of kilowatt hours generated has increased much more rapidly during the latest five-year period (121.2 per cent) than during the preceding period (98 per cent), while the rate of increase for the decade (337.8 per cent) has been far in excess of the increased capacity of dynamos. These figures, of course, point to a much more efficient utilization of generating equipment than at earlier dates.

*Commercial stations classified according to character of ownership.*—It is worth while to make some comparisons of commercial stations based on the character of ownership. As has been previously indicated, the census calls for a classification of plants in this group according to whether they are owned by individuals, firms, or corporations. In Table 10, accordingly, some of the more important relations existing between these various classes are set forth.

**Table 10** COMMERCIAL CENTRAL ELECTRIC STATIONS, BY CHARACTER OF OWNERSHIP: 1917 AND 1912.

| | Total. | | Individual. | | Firm. | | Incorporated.[1] | | Per cent of increase.[2] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1917 | 1912 | 1917 | 1912 | 1917 | 1912 | 1917 | 1912 | Total. | Individual. | Firm. | Incorporated. |
| Number of stations | 4,224 | 3,659 | 909 | 587 | 397 | 293 | 2,918 | 2,779 | 15.4 | 54.8 | 35.5 | 5.0 |
| Total income | $486,634,021 | $279,054,409 | $3,416,952 | $2,931,706 | $1,805,001 | $1,575,096 | $481,412,068 | $274,547,607 | 74.4 | 16.6 | 14.6 | 75.3 |
| Light, heat, and power | $462,473,917 | $264,474,949 | $3,347,507 | $2,812,178 | $1,766,514 | $1,517,129 | $457,359,896 | $260,145,642 | 74.9 | 19.0 | 16.4 | 75.8 |
| All other sources | $24,160,104 | $14,579,460 | $69,445 | $119,528 | $38,487 | $57,967 | $24,052,172 | $14,401,965 | 65.7 | −41.9 | −33.6 | 67.0 |
| Total expenses, including salaries and wages | $395,127,395 | $217,660,112 | $2,691,060 | $2,155,032 | $1,375,763 | $1,109,031 | $391,060,572 | $214,396,049 | 81.5 | 24.9 | 24.0 | 82.4 |
| Total number of persons employed | 94,679 | 71,395 | 1,101 | 1,097 | 591 | 576 | 92,987 | 69,722 | 32.6 | 0.4 | 2.6 | 33.4 |
| Prime movers: | | | | | | | | | | | | |
| Number of units | 10,387 | 9,326 | 1,257 | 869 | 586 | 465 | 8,544 | 7,992 | 11.4 | 44.6 | 26.0 | 6.9 |
| Total horsepower | 12,077,657 | 6,970,716 | 79,475 | 87,455 | 48,113 | 48,404 | 11,950,069 | 6,834,857 | 73.3 | −9.1 | −0.6 | 74.8 |
| Steam engines (including turbines)— | | | | | | | | | | | | |
| Number | 5,287 | 5,823 | 326 | 479 | 168 | 255 | 4,793 | 5,089 | −9.2 | −32.0 | −34.1 | −5.8 |
| Horsepower | 7,852,205 | 4,543,112 | 32,056 | 57,234 | 18,905 | 29,717 | 7,801,244 | 4,456,161 | 72.8 | −44.0 | −36.4 | 75.1 |
| Water wheels— | | | | | | | | | | | | |
| Number | 3,109 | 2,670 | 229 | 198 | 122 | 100 | 2,758 | 2,372 | 16.4 | 15.6 | 22.0 | 16.3 |
| Horsepower | 4,076,878 | 2,338,970 | 24,754 | 22,141 | 18,083 | 14,151 | 4,034,041 | 2,302,678 | 74.3 | 11.8 | 27.8 | 75.2 |
| Internal-combustion engines— | | | | | | | | | | | | |
| Number | 1,991 | 833 | 702 | 192 | 296 | 110 | 993 | 531 | 139.0 | 265.6 | 169.1 | 87.0 |
| Horsepower | 148,574 | 88,634 | 22,665 | 8,080 | 11,125 | 4,536 | 114,784 | 76,018 | 67.6 | 180.5 | 145.3 | 51.0 |
| Dynamos: | | | | | | | | | | | | |
| Number | 9,991 | 9,843 | 1,171 | 861 | 528 | 401 | 8,292 | 8,581 | 1.5 | 36.0 | 31.6 | −3.4 |
| Kilowatt capacity | 8,411,944 | 4,768,762 | 50,951 | 60,023 | 29,307 | 29,577 | 8,331,686 | 4,679,162 | 76.4 | −15.1 | −0.9 | 78.0 |
| Output of stations: | | | | | | | | | | | | |
| Kilowatt hours generated | 24,398,983,183 | 11,031,583,155 | 52,992,568 | 60,058,813 | 45,439,508 | 37,951,228 | 24,300,551,107 | 10,933,573,114 | 121.2 | −11.8 | 19.7 | 122.2 |
| Kilowatt hours purchased | 5,413,207,563 | 2,524,922,228 | 7,687,970 | 3,013,190 | 4,587,703 | 1,917,149 | 5,400,931,890 | 2,519,991,889 | 114.4 | 155.1 | 139.3 | 114.3 |
| Number of customers | 6,202,189 | 3,311,870 | 92,995 | 71,448 | 49,437 | 41,455 | 6,059,757 | 3,198,967 | 87.3 | 30.2 | 19.2 | 89.4 |

[1] In 1917 includes 6 stations classed as "other forms of ownership," and in 1912, 7 such stations.

[2] A minus sign (−) denotes decrease.

Perhaps attention should first be called to the marked increase in the number of plants operated by individuals and firms during the period 1912–1917, amounting to 426, as opposed to an increase of only 139 for corporations, or 75.4 per cent of the aggregate increase in the number of commercial plants. Hence it appears that by far the greater part of the new plants erected have been absorbed by already existing corporations. The rate of increase amounted to 54.8 per cent for individual plants and 35.5 per cent for the firms, while for incorporated plants the increase was only 5 per cent. It should further be noted that between 1907 and 1912 there was an actual decrease in the number of individual plants and firms.

The marked increase in number since 1912 was scarcely to be expected and is not readily accounted for. It is probably true, however, that many plants beginning operation without incorporation, which would normally become incorporated during the period, have retained their original form of organization with a view to avoiding certain Federal and local taxes, a situation which would not have existed in normal times. Further, it may be that a number of small stations have given up their charters and are operating as firms at the present time for similar reasons. Again, judging by the remarkably great increase in the number and horsepower of internal-combustion engines in these plants, together with the marked decrease in the number and horsepower of steam engines and turbines, in many districts it may have been found profitable, as the cost of coal was rising, to establish those small plants which are easily operated by gas and oil engines, with a view to supplying electrical current to a population which had not been previously served. Further, because of the greatly increased cost of copper and all equipment needed for the extension of lines, many large plants, which would normally have extended their operations into more or less distant territory, have found it unprofitable to do so, with the result that the establishment of lighting plants by small interests in connection with some other business has been greatly fostered. Finally, mention should be made of the fact that these forms of ownership are by far the most common in the West North Central division, comprising the states of Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas, where distances between population centers are frequently great, large central stations are not numerous, coal can not be economically supplied, and there is little opportunity for hydroelectric development. In a number of these states both oil and natural gas are readily accessible. The individual and firm ownership is also common in the West South Central division, where the conditions are in many ways similar to those found in the West North Central division, and where, in addition, there is throughout a large and cheap supply of oil and natural gas. Finally, in the more populous states of Ohio, Illinois, Michigan, and New York are found a relatively large number of these plants, the greatest number being in Ohio and Illinois, where there is a good supply of either gas or oil and where bituminous coal is comparatively low in price.

A further examination of the table discloses the fact that the increase in the leading items for individual plants and firms has by no means kept pace with the increase in the number of such stations. In fact, in a number of cases there has been an actual decrease. The total horsepower of prime movers was less for both classes in 1917 than in 1912, though the number of units had increased by a very appreciable amount, 44.6 per cent for individual plants and 26 per cent for firms. Again, there was a decrease of 15.1 per cent in the kilowatt capacity of dynamos in the former and a decrease of 11.8 per cent in the number of kilowatt hours generated, in spite of the 54.8 per cent increase in the number of plants. On the other hand, the amount of current purchased in both cases increased rapidly. In all important respects, however, individuals and firms, in the aggregate, have grown relatively far less important in the electrical industry than they were at earlier periods.

The relative conditions of commercial plants, according to the character of ownership, are clearly shown in Table 11.

**Table 11** COMMERCIAL CENTRAL ELECTRIC STATIONS—AVERAGES PER PLANT FOR 1917, AND PER CENT OF TOTAL ACCORDING TO CHARACTER OF OWNERSHIP FOR 1917 AND 1912.

| | Average per plant, 1917. | | | Per cent of total. | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Individual. | Firm. | Incorporated. | Individual. | | Firm. | | Incorporated. | |
| | | | | 1917 | 1912 | 1917 | 1912 | 1917 | 1912 |
| Number of stations | | | | 21.5 | 16.0 | 9.4 | 8.0 | 69.1 | 76.0 |
| Income | $3,759 | $4,547 | $164,980 | 0.7 | 1.0 | 0.4 | 0.6 | 98.9 | 98.4 |
| Horsepower of prime movers | 87 | 121 | 4,095 | 0.7 | 1.3 | 0.4 | 0.7 | 98.9 | 98.0 |
| Kilowatt capacity of dynamos | 56 | 74 | 2,855 | 0.6 | 1.3 | 0.3 | 0.6 | 99.0 | 98.1 |
| Kilowatt hours generated | 58,297 | 114,457 | 8,327,811 | 0.2 | 0.5 | 0.2 | 0.3 | 99.6 | 99.1 |
| Number of customers | 102 | 125 | 2,077 | 1.5 | 2.2 | 0.8 | 1.3 | 97.7 | 96.6 |

It appears that the average income of incorporated stations was, in 1917, $164,980, between forty and fifty times as great as the average income of individual plants, $3,759; nor did the firms average much larger than the other group of plants. The averages which show the least difference are those for number of customers served, the figures for which were 102 and 125 for individuals and firms, respectively, and 2,077 for corporations. The widest difference, however, is to be found in the number of kilowatt hours generated, which averages 8,327,811 for incorporated plants, an amount which is nearly seventy-three times as great as that generated by the average firm, and more than one hundred and forty times as great as that produced by the average plant under individual ownership. The table further shows that the relative importance of these smaller stations as compared with the incorporated plants has in all respects grown less during the past five years, and that the two together do only from less than 1 to 2.3 per cent of the entire electric station business of the country.

*Municipal central electric stations.*—It is of some interest to make a separate study of the general growth of municipal central electric stations. From Table 12 it appears that the rate of increase in the number of stations and in the investment in plant and equipment has been more marked during the decade than for the commercial plants. From 1912 to 1917, particularly, the number of plants increased almost as rapidly as the total investment (48.4 per cent and 65.3 per cent, respectively), whereas at both periods the growth in the investment in commercial plants has far outrun the increase in the number of stations.

**Table 12**

| | MUNICIPAL CENTRAL ELECTRIC STATIONS. | | | | | |
|---|---|---|---|---|---|---|
| | 1917 | 1912 | 1907 | Per cent of increase.[1] | | |
| | | | | 1907–1917 | 1912–1917 | 1907–1912 |
| Number of stations | 2,318 | 1,562 | 1,252 | 85.1 | 48.4 | 24.8 |
| Value of plant and equipment | $127,375,209 | $77,065,144 | $42,879,447 | 197.1 | 65.3 | 79.7 |
| Total income | $40,260,219 | $23,218,989 | $14,011,999 | 187.3 | 73.4 | 65.7 |
| Light, heat, and power, including free service | $39,586,063 | $22,663,708 | $13,614,434 | 190.8 | 74.7 | 66.5 |
| All other sources | $674,156 | $555,281 | $397,565 | 69.6 | 21.4 | 39.7 |
| Total expenses, including salaries and wages [2] | $31,440,912 | $16,917,165 | $10,316,620 | 204.8 | 85.8 | 64.0 |
| Total number of persons employed | 10,862 | 7,940 | 5,566 | 95.1 | 36.8 | 42.7 |
| *Prime movers:* | | | | | | |
| Number | 3,408 | 2,576 | 2,017 | 69.0 | 32.3 | 27.7 |
| Total horsepower | 859,098 | 559,328 | 321,351 | 167.3 | 53.6 | 74.1 |
| Steam engines and steam turbines— | | | | | | |
| Number | 2,200 | 2,024 | 1,786 | 23.2 | 8.7 | 13.3 |
| Horsepower | 596,871 | 406,666 | 284,922 | 109.5 | 46.8 | 42.7 |
| Water wheels— | | | | | | |
| Number | 265 | 269 | 153 | 73.2 | —1.5 | 75.8 |
| Horsepower | 200,395 | 130,261 | 30,347 | 560.3 | 53.8 | 329.2 |
| Internal-combustion engines— | | | | | | |
| Number | 943 | 283 | 78 | ..... | 233.2 | ..... |
| Horsepower | 61,832 | 22,401 | 6,082 | 916.6 | 176.0 | 268.3 |
| Dynamos: | | | | | | |
| Number | 3,437 | 2,767 | 2,395 | 43.5 | 24.2 | 15.5 |
| Kilowatt capacity | 582,403 | 396,677 | 209,016 | 178.7 | 46.8 | 89.8 |
| Output of stations: | | | | | | |
| Kilowatt hours generated | 1,039,320,089 | 537,526,730 | 289,462,788 | 259.1 | 93.4 | 85.7 |
| Kilowatt hours purchased | 192,538,399 | 88,580,377 | [3] | ..... | 117.4 | ..... |
| Number of street lamps: | | | | | | |
| Arc | 49,993 | 84,491 | [4] | ..... | —40.8 | ..... |
| Incandescent and other varieties | 422,575 | 207,469 | [4] | ..... | 103.7 | ..... |
| Stationary motors served: | | | | | | |
| Number | 51,060 | 21,895 | 4,507 | 1,032.9 | 133.2 | 385.8 |
| *Horsepower capacity* | 425,623 | 164,201 | 31,689 | 1,243.1 | 159.1 | 418.4 |
| Number of customers | 976,514 | 525,648 | 283,625 | 244.3 | 85.8 | 85.3 |

[1] A minus sign (—) denotes decrease. Percentages are omitted when base is less than 100.
[2] In addition to salaries and wages, includes cost of supplies and materials used for ordinary repairs and replacement, advertising, fuel, mechanical power, electrical energy purchased, taxes, charges for depreciation, and all other expenses incident to operation and maintenance.
[3] Not reported.
[4] *Figures not available.*

It is interesting also to examine in somewhat more detail the increase in number of municipal plants between 1912 and 1917. Accordingly, from Table 13 it appears that the number of new stations installed since 1912 was 728, or 46.6 per cent of the total number reporting in 1912, and, in addition, 131 plants changed from commercial to municipal ownership during the period. This would indicate a total increase of 859 plants. From this number, however, must be deducted 25 municipal stations which changed to commercial ownership, 72 which combined with other plants or with street railways, and 6 which appear to have been out of business or not operated in 1917. This makes a total deduction of 103 plants, leaving an actual numerical increase of 756. It should be further noted that in order to make itemized figures for 1917 comparable with the data given in 1912, certain explanations are needed. Of the municipal plants which have been combined with other plants, 25 were combined with commercial stations and 9 with street railways, making a total of 34 which should be added to those changed from municipal ownership in 1912 to commercial ownership in 1917. This gives us a figure of 59 changes in ownership, more or less comparable with the 80 plants which, between 1907 and 1912, changed from municipal to

private ownership. Also, of the total number combined with other plants the remaining 38 were united with municipal stations. For comparative purposes these may properly be considered with the 6 stations active in 1912 but out of business or not operated in 1917. These calculations would give a total of 103 municipal plants which reported separately to the Census Bureau in 1912 but did not so report in 1917, as compared with a total of 97 such plants which reported separately in 1907 but which changed ownership, were combined with other stations, or were not operated in 1912.

**Table 13** NUMBER OF MUNICIPAL CENTRAL ELECTRIC STATIONS AND INCREASE, BY GEOGRAPHIC DIVISIONS: 1912 TO 1917.

| DIVISION.[1] | Number of stations. | | | New stations since 1912. | From commercial stations in 1912 to municipal in 1917. | From municipal stations in 1912 to commercial in 1917. | Stations that have been combined with other stations or with street railways since 1912. | Active municipal stations in 1912 that were out of business or not operated in 1917. |
|---|---|---|---|---|---|---|---|---|
| | 1917 | 1912 | Numerical increase. | | | | | |
| United States. | 2,318 | 1,562 | 756 | 728 | 131 | 25 | 72 | 6 |
| New England | 72 | 57 | 15 | 10 | 6 | ..... | 1 | ..... |
| Middle Atlantic | 123 | 102 | 21 | 19 | 7 | 1 | 3 | 1 |
| East North Central | 567 | 474 | 93 | 114 | 21 | 6 | 35 | 1 |
| West North Central | 760 | 399 | 361 | 344 | 49 | 9 | 22 | 1 |
| South Atlantic | 330 | 204 | 126 | 112 | 10 | 1 | 1 | 3 |
| East South Central | 154 | 128 | 26 | 24 | 10 | 2 | 6 | ..... |
| West South Central | 191 | 122 | 69 | 62 | 13 | 4 | 2 | ..... |
| Mountain | 73 | 39 | 34 | 31 | 6 | 2 | 1 | ..... |
| Pacific | 48 | 37 | 11 | 12 | ..... | ..... | 1 | ..... |

[1] See p. 18 for states composing the several geographic divisions.

In passing, mention should be made of the fact that, in 1917, 541 municipal plants, or 23.3 per cent of the total, purchased all of their current, as opposed to 136 such plants in 1912. Also, 67 plants did only a street or park lighting business, while 7 others did both a lighting and a small power business for the municipality itself, without having any commercial customers. The most marked increase in the number of municipal stations from 1912 to 1917 has been in the West North Central division—in fact, the increase in this one section (361 plants) was almost equal to that in all other sections combined. There was also an appreciable addition in the South Atlantic division (126), followed by the East North Central (93) and the West South Central (69). The changes from commercial to municipal ownership were also most numerous in these divisions, as well as the changes from municipal to commercial ownership. A large majority of the combinations occurred in the East North Central and West North Central divisions.

In 1917 the West North Central division had 760 municipal plants, or nearly one-third of the total, while this division and the East North Central together reported 57.2 per cent of all municipal stations. Nine states—Kansas, Nebraska, Ohio, Iowa, Minnesota, Georgia, Illinois, Michigan, and Oklahoma—had more than 100 municipal plants each, Kansas heading the list with 186. All states showed some increase in the number of plants under public ownership except Rhode Island, Connecticut, and Nevada, which experienced no change, and Delaware, which decreased. The greatest individual increases since 1912 are found in Kansas (104), in Nebraska (87), and in Iowa (79), while the states nearest approaching these are Georgia (44), Oklahoma (43), North Carolina (32), Ohio (31), and Minnesota (29).

Finally, it is interesting to find that in 1917 there were 8 states in which the number of municipal stations exceeded the number of commercial stations. This excess is most marked in Georgia, where it is 80, and in Kansas, with an excess of 70. Both Minnesota and Oklahoma have 11 more municipal than commercial plants, while in the remaining states the differences are less marked. In South Carolina there are an equal number of commercial and municipal plants (41).

At first glance it may be somewhat surprising to find so great an increase in the number of municipal plants as compared with commercial plants. It should be remembered, however, that practically all of these new publicly owned plants are very small, and there has been almost no combination among municipal stations. Hence, in general, every numerical increase represents only one station and one new locality served, whereas in the commercial companies an increase of one may mean a union of several stations or systems and a new territory served embracing many separate municipalities, which, without such combination and distribution of current over long distances, would have found it necessary to install local stations or go without electric current entirely. Further, the most rapid increase in the number of municipal plants has taken place in those less densely populated states where for natural reasons there has been comparatively little large-scale production or combination in the industry.

Some of the suggestions made regarding the growth in number, though not in relative importance, of "individual" plants and "firms" will apply to municipal stations as well. In Kansas, Nebraska, Oklahoma, and Ohio oil or natural gas, or both, are widely and profitably used in small stations, while in Georgia it is customary to utilize waste products from the lumber mills, which make a very inexpensive fuel supply. In none of the stations where increases have been numerous, except in North Carolina, was there to be found before 1917 any hydroelectric development of importance, and in many instances it is probable that the municipalities in question could have had no electric service whatever had they not installed their own plants.

Finally, it is no doubt true that, in the period of rapidly rising prices, many small municipalities were induced to invest in electric plants of their own, even though they might have been served by commercial stations, in the hope that they might thereby effect a saving to the community. So far as the more advanced industrial districts are concerned, however, it appears that in them few municipalities have installed generating plants since 1912, but have merely constructed distributing systems and have relied upon adjoining commercial companies to supply them with electric power. The state of Massachusetts is a typical instance of this tendency, in which the 8 municipal plants established since 1912 all purchase their current. The general trend in this direction is further indicated by the fact that, while in 1912 those municipal plants purchasing all their current comprised only 8.7 per cent of the total, the proportion had increased to 23.3 per cent in 1917.

To return to Table 12, a further examination discloses the fact that while between 1912 and 1917, the rate of increase in total income of municipal plants exceeded the increase in investment (73.4 per cent as opposed to 65.3 per cent), the reverse situation existed in the earlier five-year period, during which time the total income increased only 65.7 per cent, while the investment showed a gain of 79.7 per cent. It is also interesting to find that while the rate of increase in expenses lagged somewhat behind the increase in income between 1907 and 1912, during the latest five-year period the expenses increased 85.8 per cent, or absolutely 12.4 per cent more rapidly than the income. This is a much more marked difference than exists in the case of the commercial plants, where the increase in expenses outstripped the income by only 7.1 per cent. It is somewhat surprising to find that, though there was a 65.3 per cent increase in investment between 1912 and 1917, the rate of increase in the total horsepower of prime movers was only 53.6 per cent and in the kilowatt capacity of dynamos 46.8 per cent. As the industry becomes seasoned, it would be normal to expect a much less rapid increase in the investment as compared with the increase in physical capacity of plants, as is the case in the commercial stations, in which the growth in horsepower of prime movers and kilowatt capacity of dynamos was almost twice as rapid between 1912 and 1917 as the increase in investment. Though during the earlier period there was a much closer relation between these three items, it would appear that at present the increases in investment are not resulting in increased capacity of stations. This condition, of course, is partially accounted for by the comparatively rapid growth in those municipal plants which own only a distributing system. These new plants, however, are in the main much smaller than the average municipal plant and would not vitally affect the situation. The number of kilowatt hours generated has increased 93.4 per cent during the latest period, as opposed to 85.7 per cent at the earlier date. In neither case, however, has the increase been so marked as for the commercial plants. The most marked development has been in the increase in number and capacity of stationary motors served, which during the decade amounted to more than 1,000 per cent. The number of customers has increased at almost identical rates during both periods.

Table 14 shows, for the three periods 1917, 1912, and 1907, the relative importance of commercial and municipal stations so far as the leading items are concerned.

**Table 14** — PER CENT OF TOTAL, COMMERCIAL AND MUNICIPAL STATIONS.

| | Commercial. | | | Municipal. | | |
|---|---|---|---|---|---|---|
| | 1917 | 1912 | 1907 | 1917 | 1912 | 1907 |
| Number of stations | 64.6 | 70.1 | 73.4 | 35.4 | 29.9 | 26.6 |
| Value of plant and equipment | 95.8 | 96.5 | 96.1 | 4.2 | 3.5 | 3.9 |
| Total income | 92.4 | 92.3 | 92.0 | 7.6 | 7.7 | 8.0 |
| Light, heat, and power, including free service | 92.1 | 92.1 | 92.0 | 7.9 | 7.9 | 8.0 |
| All other sources | 97.3 | 96.3 | 93.4 | 2.7 | 3.7 | 6.6 |
| Total expenses, including salaries and wages | 92.6 | 92.8 | 92.3 | 7.4 | 7.2 | 7.7 |
| Total number of persons employed | 89.7 | 90.0 | 88.3 | 10.3 | 10.0 | 11.7 |
| Prime movers: | | | | | | |
| Number | 75.3 | 78.4 | 81.7 | 24.7 | 21.6 | 18.3 |
| Total horsepower | 93.4 | 92.6 | 92.2 | 6.6 | 7.4 | 7.8 |
| Steam engines and steam turbines | 92.9 | 91.8 | 89.4 | 7.1 | 8.2 | 10.6 |
| Water wheels | 95.3 | 94.7 | 97.8 | 4.7 | 5.3 | 2.2 |
| Internal-combustion engines | 70.6 | 79.3 | 89.1 | 29.4 | 20.2 | 10.9 |
| Dynamos: | | | | | | |
| Number | 74.4 | 78.1 | 80.3 | 25.6 | 21.9 | 19.7 |
| Kilowatt capacity | 93.5 | 92.3 | 92.3 | 6.5 | 7.7 | 7.7 |
| Output of stations (total) | 96.0 | 95.6 | (1) | 4.0 | 4.4 | (1) |
| Kilowatt hours generated | 95.9 | 95.4 | 95.1 | 4.1 | 4.6 | 4.9 |
| Kilowatt hours purchased | 96.6 | 96.6 | (1) | 3.4 | 3.4 | (1) |
| Number of street lamps: | | | | | | |
| Arc | 80.5 | 75.8 | (1) | 19.5 | 24.2 | (1) |
| Incandescent and other varieties | 69.6 | 69.6 | (1) | 30.4 | 30.4 | (1) |
| Stationary motors served: | | | | | | |
| Number | 90.8 | 95.0 | 97.3 | 9.2 | 5.0 | 2.7 |
| Horsepower capacity | 95.4 | 96.0 | 98.1 | 4.6 | 4.0 | 1.9 |
| Number of meters | 86.9 | 87.0 | 87.2 | 13.1 | 13.0 | 12.8 |
| Number of customers | 86.4 | 86.3 | 85.4 | 13.6 | 13.7 | 14.6 |

[1] Figures not available.

In the first place, it appears that there has been a steady though not particularly marked increase in the proportionate number of municipal stations, from 26.6 per cent of the total in 1907 to 35.4 per cent in 1917. There has also been a very slight increase in the relative amount of investment in publicly owned plants, from 3.9 per cent in 1907 to 4.2 per cent 10 years later, though there was an unexpected drop to only 3.5 in 1912. Aside from these two items, however, in every vital aspect, except in the horsepower capacity of stationary motors served, the municipal plants have shown a more or less pronounced decrease in the relative importance of their equipment and operations. This proportionate decrease has been most marked in horsepower capacity of prime movers, which dropped from 7.8 per cent of the total for commercial and municipal stations in 1907 to only 6.6 in 1917, and in the kilowatt capacity of dynamos, which decreased from 7.7 per cent to 6.5 per cent during the decade. In the kilowatt hours generated, also,

the decrease has been marked, from 4.9 per cent of the total at the earlier period to only 4.1 in 1917. Even the number of customers has decreased from 14.6 per cent to 13.6 per cent.

**Table 15** COMMERCIAL AND MUNICIPAL CENTRAL ELECTRIC STATIONS—AVERAGES AND PER CENT OF INCREASE: 1917 AND 1912.

| | Commercial. | | | Municipal. | | |
|---|---|---|---|---|---|---|
| | Average per plant. | | Per cent of increase. | Average per plant. | | Per cent of increase.[1] |
| | 1917 | 1912 | | 1917 | 1912 | |
| Value of plant and equipment | $694,370 | $573,548 | 21.1 | $54,950 | $49,337 | 11.4 |
| Total income | $115,207 | $76,265 | 51.1 | $17,369 | $14,865 | 16.8 |
| Total horsepower | 2,859 | 1,905 | 50.1 | 371 | 358 | 3.6 |
| Kilowatt capacity of dynamos | 1,991 | 1,303 | 52.8 | 251 | 254 | −1.2 |
| Kilowatt hours generated | 5,776,274 | 3,014,918 | 91.6 | 448,369 | 344,127 | 30.3 |
| Kilowatt hours purchased | 1,281,536 | 690,058 | 85.7 | 83,062 | 56,710 | 46.5 |
| Number of customers | 1,468 | 905 | 62.2 | 421 | 337 | 24.9 |

[1] A minus sign (−) denotes decrease.

Perhaps Table 15, which shows the average size per commercial and municipal plant in 1917 and 1912, together with the per cent of increase in some of the important items during the period, will aid in showing more clearly just what has been happening comparatively in the electric light and power industry. Accordingly, it appears that the rate of increase in investment per plant has been almost twice as rapid for commercial stations (21.1 per cent) as for municipal stations (11.4 per cent), but it further appears that the total average horsepower has increased almost fourteen times as rapidly in the commercial plants (50.1 per cent as opposed to 3.6 per cent), while comparison is utterly impossible in the case of dynamo capacity, since for the commercial plants there was an increase of 52.8 per cent, while for municipal plants there was an actual decrease of 1.2 per cent. In the number of kilowatt hours generated, also, the average commercial plant shows an increase of 91.6 per cent, which is more than three times as rapid a rate as the increase of 30.3 per cent shown by the municipal plants. Finally, even in the number of customers, commercial plants have shown an increase two and one-half times as rapid as that of the other group. All these comparisons point to the facts, first, that the average size of commercial plants has increased far more rapidly than that of municipal plants, and, secondly, that the former are apparently doing a much more extensive business relative to their increase in investment.

*Purely electric and composite stations contrasted.*—It is interesting to make some comparisons between purely electric and composite stations. As indicated in Chapter I, a "composite station" is one which is operated in connection with some other industry which may be more or less important from a financial point of view than the electrical part of the business. Commonly, the operations carried on with that of furnishing electric current are those of supplying water and producing gas or conducting a street railway enterprise. Frequently, however, enterprises not of a public service nature, such as the manufacture of ice, are found in connection with central station activities. The prevailing condition is shown by the following statement:

COMPOSITE PLANTS—CHARACTER OF SERVICE: 1917.

| *Character of service.* | *Number of stations.* |
|---|---|
| Electric and water | 1,328 |
| Electric and gas | 206 |
| Electric, gas, and water | 32 |
| Electric, gas, and street railway | 14 |
| Electric and street railway | 11 |
| Electric, gas, water, and street railway | 6 |
| Electric, water, and street railway | 4 |
| Electric and miscellaneous business, such as heating, manufacture of ice, mining, telephones, etc. | 1,064 |

PURELY ELECTRIC AND COMPOSITE CENTRAL ELECTRIC STATIONS—COMMERCIAL AND MUNICIPAL: 1917, 1912, AND 1907.

| **Table 16** | Census year. | Aggregate. | PURELY ELECTRIC STATIONS. | | | COMPOSITE STATIONS. | | |
|---|---|---|---|---|---|---|---|---|
| | | | Total. | Commercial. | Municipal. | Total. | Commercial. | Municipal. |
| Number of stations | 1917 | 6,542 | 3,877 | 2,787 | 1,090 | 2,665 | 1,437 | 1,228 |
| | 1912 | 5,221 | 2,772 | 2,209 | 563 | 2,449 | 1,450 | 999 |
| | 1907 | 4,714 | 2,648 | 2,127 | 521 | 2,066 | 1,335 | 731 |
| Per cent of increase, 1907–1917 | | 38.8 | 46.4 | 31.0 | 109.2 | 29.0 | 7.6 | 68.0 |
| Cost of construction and equipment | 1917 | $3,060,392,141 | $1,733,705,700 | $1,672,794,913 | $60,910,787 | $1,326,686,441 | $1,260,222,028 | $66,464,413 |
| | 1912 | $2,175,678,266 | $1,128,330,859 | $1,105,111,379 | $23,219,480 | $1,047,347,407 | $993,501,743 | $53,845,664 |
| | 1907 | $1,096,913,622 | $662,926,914 | $639,437,274 | $23,489,640 | $433,986,708 | $414,506,901 | $19,480,807 |
| Per cent of increase, 1907–1917 | | 179.0 | 161.5 | 161.6 | 159.3 | 205.7 | 204.0 | 242.8 |
| Total income | 1917 | $526,894,240 | $306,328,777 | $288,791,787 | $17,536,990 | $220,565,463 | $197,842,234 | $22,723,229 |
| | 1912 | $302,273,398 | $159,343,653 | $151,673,537 | $7,670,116 | $142,929,745 | $127,380,872 | $15,548,873 |
| | 1907 | $175,642,338 | $107,974,921 | $101,222,267 | $6,752,654 | $67,667,417 | $60,408,072 | $7,259,345 |
| Per cent of increase, 1907–1917 | | 200.0 | 183.7 | 185.3 | 159.7 | 226.0 | 227.5 | 213.0 |
| Light, heat, and power | 1917 | $502,059,980 | $293,696,971 | $276,452,158 | $17,244,813 | $208,363,009 | $186,021,759 | $22,341,250 |
| | 1912 | $287,138,657 | $152,751,014 | $145,276,466 | $7,474,548 | $134,387,643 | $119,198,483 | $15,189,160 |
| | 1907 | $169,614,691 | $104,629,574 | $98,056,838 | $6,572,736 | $64,985,117 | $57,943,419 | $7,041,698 |
| Per cent of increase, 1907–1917 | | 196.0 | 180.7 | 181.9 | 162.4 | 220.6 | 221.0 | 217.3 |
| All other sources | 1917 | $24,834,260 | $12,631,806 | $12,339,629 | $292,177 | $12,202,454 | $11,820,475 | $381,979 |
| | 1912 | $15,134,741 | $6,592,639 | $6,397,071 | $195,568 | $8,542,102 | $8,182,389 | $359,713 |
| | 1907 | $6,027,647 | $3,345,347 | $3,165,429 | $179,918 | $2,682,300 | $2,464,653 | $217,647 |
| Per cent of increase, 1907–1917 | | 312.0 | 277.6 | 289.8 | 62.4 | 354.9 | 379.6 | 75.5 |

PURELY ELECTRIC AND COMPOSITE CENTRAL ELECTRIC STATIONS—COMMERCIAL AND MUNICIPAL: 1917, 1912, AND 1907—Continued.

**Table 16**—Continued.

| | Census year. | Aggregate | PURELY ELECTRIC STATIONS. | | | COMPOSITE STATIONS. | | |
|---|---|---|---|---|---|---|---|---|
| | | | Total. | Commercial. | Municipal. | Total. | Commercial. | Municipal. |
| Total expenses, including salaries and wages | 1917 | $426,568,307 | $249,871,295 | $235,002,731 | $14,268,564 | $176,697,012 | $159,524,664 | $17,172,348 |
| | 1912 | $234,577,277 | $122,322,345 | $116,574,761 | $5,747,584 | $112,254,932 | $101,085,351 | $11,169,581 |
| | 1907 | $134,196,911 | $76,238,037 | $71,411,336 | $4,826,701 | $57,958,874 | $52,468,955 | $5,489,919 |
| Per cent of increase, 1907–1917 | | 217.9 | 227.8 | 229.9 | 195.6 | 204.9 | 204.0 | 212.8 |
| Total number of persons employed | 1917 | 105,541 | 58,491 | 54,004 | 4,487 | 47,050 | 40,675 | 6,375 |
| | 1912 | 79,335 | 40,117 | 37,635 | 2,482 | 39,218 | 33,760 | 5,458 |
| | 1907 | 47,632 | 27,524 | 24,968 | 2,556 | 20,108 | 17,098 | 3,010 |
| Per cent of increase, 1907–1917 | | 121.6 | 112.5 | 116.3 | 75.5 | 134.0 | 137.9 | 111.8 |
| Total horsepower | 1917 | 12,936,755 | 7,966,317 | 7,552,963 | 413,354 | 4,970,438 | 4,524,694 | 445,744 |
| | 1912 | 7,530,044 | 4,006,189 | 3,831,835 | 174,354 | 3,523,855 | 3,138,881 | 384,974 |
| | 1907 | 4,098,188 | 2,473,311 | 2,324,293 | 149,018 | 1,624,877 | 1,452,544 | 172,333 |
| Per cent of increase, 1907–1917 | | 215.7 | 222.1 | 225.0 | 177.4 | 205.9 | 211.5 | 158.7 |
| Steam engines and steam turbines— | | | | | | | | |
| Number | 1917 | 7,487 | 3,140 | 2,463 | 677 | 4,347 | 2,824 | 1,523 |
| | 1912 | 7,847 | 3,385 | 2,773 | 612 | 4,462 | 3,050 | 1,412 |
| | 1907 | 8,054 | 4,169 | 3,467 | 702 | 3,885 | 2,801 | 1,084 |
| Per cent of increase,[1] 1907–1917 | | −7.0 | −24.7 | −29.0 | −3.6 | 11.9 | 0.8 | 40.5 |
| Horsepower | 1917 | 8,449,076 | 5,131,443 | 4,866,314 | 265,129 | 3,317,633 | 2,985,891 | 331,742 |
| | 1912 | 4,949,778 | 2,489,970 | 2,350,919 | 139,051 | 2,459,808 | 2,192,193 | 267,615 |
| | 1907 | 2,693,273 | 1,583,978 | 1,459,569 | 124,409 | 1,109,295 | 948,782 | 160,513 |
| Per cent of increase, 1907–1917 | | 213.7 | 224.0 | 233.4 | 113.1 | 199.1 | 214.7 | 106.7 |
| Water wheels— | | | | | | | | |
| Number | 1917 | 3,374 | 1,964 | 1,820 | 144 | 1,410 | 1,289 | 121 |
| | 1912 | 2,939 | 1,666 | 1,557 | 109 | 1,273 | 1,113 | 160 |
| | 1907 | 2,481 | 1,575 | 1,491 | 84 | 906 | 837 | 69 |
| Per cent of increase, 1907–1917 | | 36.0 | 24.7 | 22.1 | 71.4 | 55.6 | 54.0 | 75.4 |
| Horsepower | 1917 | 4,277,273 | 2,727,109 | 2,604,697 | 122,412 | 1,550,164 | 1,472,181 | 77,983 |
| | 1912 | 2,469,231 | 1,454,976 | 1,429,148 | 25,828 | 1,014,255 | 909,822 | 104,433 |
| | 1907 | 1,349,087 | 863,885 | 842,072 | 21,813 | 485,202 | 476,668 | 8,534 |
| Per cent of increase, 1907–1917 | | 217.0 | 215.7 | 209.3 | 461.2 | 219.5 | 208.8 | 813.8 |
| Internal-combustion engines— | | | | | | | | |
| Number | 1917 | 2,034 | 1,855 | 1,394 | 461 | 1,079 | 597 | 482 |
| | 1912 | 1,116 | 667 | 555 | 112 | 449 | 278 | 171 |
| | 1907 | 463 | 295 | 262 | 33 | 168 | 123 | 45 |
| Per cent of increase, 1907–1917 | | 533.7 | 528.8 | 432.1 | 1,297.0 | 542.3 | 385.4 | 971.1 |
| Horsepower | 1917 | 210,406 | 107,765 | 81,952 | 25,813 | 102,641 | 66,622 | 36,019 |
| | 1912 | 111,035 | 61,243 | 51,768 | 9,475 | 49,792 | 36,866 | 12,926 |
| | 1907 | 55,828 | 25,448 | 22,652 | 2,796 | 30,380 | 27,094 | 3,286 |
| Per cent of increase, 1907–1917 | | 276.9 | 323.5 | 261.8 | 823.2 | 237.8 | 145.9 | 996.1 |
| Kilowatt capacity of dynamos | 1917 | 8,994,407 | 5,513,472 | 5,229,529 | 283,943 | 3,480,935 | 3,182,415 | 298,520 |
| | 1912 | 5,165,489 | 2,837,928 | 2,717,670 | 120,258 | 2,327,511 | 2,051,092 | 276,419 |
| | 1907 | 2,709,225 | 1,670,814 | 1,574,286 | 96,528 | 1,038,411 | 925,923 | 112,488 |
| Per cent of increase, 1907–1917 | | 232.0 | 230.0 | 232.2 | 194.2 | 235.2 | 243.7 | 165.4 |
| Output of stations: | | | | | | | | |
| Kilowatt hours generated[2] | 1917 | 25,438,303,272 | 16,784,522,183 | 16,214,874,887 | 569,647,296 | 8,653,781,089 | 8,184,108,296 | 469,672,793 |
| | 1912 | 11,569,109,885 | 6,638,342,395 | 6,479,811,486 | 158,530,909 | 4,930,767,490 | 4,551,771,669 | 378,995,821 |
| | 1907 | 5,862,276,737 | 3,880,087,887 | 3,734,978,340 | 145,109,547 | 1,982,188,850 | 1,837,835,609 | 144,353,241 |
| Per cent of increase, 1907–1917 | | 333.9 | 332.6 | 334.1 | 292.6 | 336.6 | 345.3 | 225.4 |
| Kilowatt hours purchased[3] | 1917 | 5,605,745,962 | 3,490,340,119 | 3,419,889,274 | 70,450,845 | 2,115,405,843 | 1,993,318,289 | 122,087,554 |
| | 1912 | 2,613,502,605 | 1,756,475,791 | 1,735,212,315 | 21,263,476 | 857,026,814 | 789,709,913 | 67,316,901 |
| Per cent of increase, 1912–1917 | | 114.5 | 98.7 | 97.1 | 231.3 | 146.8 | 152.4 | 81.4 |
| Number of street lamps:[3] | | | | | | | | |
| Arc | 1917 | 256,950 | 132,638 | 97,268 | 35,370 | 124,312 | 109,689 | 14,623 |
| | 1912 | 348,643 | 163,858 | 130,179 | 33,679 | 184,785 | 133,973 | 50,812 |
| Per cent of increase,[1] 1912–1917 | | −26.3 | −19.1 | −25.3 | 5.0 | −32.7 | −18.1 | −71.2 |
| Incandescent and other varieties | 1917 | 1,392,224 | 686,425 | 516,045 | 170,380 | 705,859 | 453,664 | 252,195 |
| | 1912 | 681,957 | 299,711 | 216,570 | 83,141 | 382,246 | 257,918 | 124,328 |
| Per cent of increase, 1912–1917 | | 104.2 | 129.0 | 138.3 | 104.9 | 84.7 | 75.9 | 102.8 |
| Stationary motors served: | | | | | | | | |
| Number | 1917 | 555,924 | 277,130 | 258,064 | 19,066 | 278,794 | 246,800 | 31,994 |
| | 1912 | 435,473 | 241,209 | 233,311 | 7,898 | 194,264 | 180,267 | 13,997 |
| | 1907 | 167,184 | 97,758 | 95,472 | 2,286 | 69,426 | 67,205 | 2,221 |
| Per cent of increase, 1907–1917 | | 232.5 | 183.5 | 170.3 | 734.0 | 301.6 | 267.2 | 1,340.5 |
| Horsepower capacity | 1917 | 9,216,330 | 5,446,524 | 5,269,853 | 176,671 | 3,769,806 | 3,520,854 | 248,952 |
| | 1912 | 4,130,619 | 2,311,509 | 2,258,131 | 53,378 | 1,819,110 | 1,708,197 | 110,913 |
| | 1907 | 1,649,026 | 1,077,484 | 1,061,190 | 16,294 | 571,542 | 556,147 | 15,395 |
| Per cent of increase, 1907–1917 | | 458.9 | 405.5 | 396.6 | 984.3 | 559.6 | 533.1 | 1,517.1 |
| Number of customers | 1917 | 7,178,703 | 3,679,513 | 3,272,756 | 406,757 | 3,499,190 | 2,929,433 | 569,757 |
| | 1912 | 3,837,518 | 1,753,626 | 1,579,146 | 174,480 | 2,083,892 | 1,732,724 | 351,168 |
| | 1907 | 1,946,979 | (4) | (4) | (4) | (4) | (4) | (4) |
| Per cent of increase, 1907–1917 | | 268.7 | | | | | | |

[1] A minus sign (−) denotes decrease. [2] In 1907 no separation was made between current generated and purchased. [3] Figures not available for 1907.

From Table 16 it appears that during the last decade purely electric stations, both commercial and municipal, have increased much more rapidly in number than composite stations. It is further significant to note that, while commercial composite stations have shown almost no increase during the decade (only 7.6 per cent) and have actually decreased nine-tenths of 1 per cent between 1912 and 1917 (from 1,450 to 1,437), municipal composite plants, on the contrary, have increased 68 per cent in number since 1907. The latter condition is to be expected, since many municipalities find it advantageous to operate an electric light plant in connection with a water-supply system or a gas plant already munici-

pally owned, thus effecting a considerable saving at times in overhead expenses as a result of combined administration and frequently utilization of the same buildings for different purposes. In practically all of the important items, also, the composite stations of all kinds appear to have experienced an increase often more rapid than that shown by purely electric plants. It must be noted, however, that most of the more marked developments came during the earlier five-year period 1907–1912.

Perhaps the relative importance of composite and purely electric stations, both in the aggregate and according to the character of ownership, can best be shown by Table 17, in which the per cent which each group forms of the total is set forth for the years 1917 1912, and 1907.

**Table 17** PURELY ELECTRIC AND COMPOSITE CENTRAL ELECTRIC STATIONS—PER CENT OF TOTAL: 1917, 1912, AND 1907.

| | Census year. | Purely electric stations. | | | Composite stations. | | |
|---|---|---|---|---|---|---|---|
| | | Per cent of aggregate. | Per cent of total. | | Per cent of aggregate. | Per cent of total. | |
| | | Total. | Commercial. | Municipal. | Total. | Commercial. | Municipal. |
| Number of stations | 1917 | 59.3 | 71.9 | 28.1 | 40.7 | 53.0 | 46.1 |
| | 1912 | 53.1 | 79.7 | 20.3 | 46.9 | 59.2 | 40.8 |
| | 1907 | 56.2 | 80.3 | 19.7 | 43.8 | 64.6 | 35.4 |
| Value of plant and equipment | 1917 | 56.6 | 96.5 | 3.5 | 43.4 | 95.0 | 5.0 |
| | 1912 | 51.9 | 97.9 | 2.1 | 48.1 | 94.9 | 5.1 |
| | 1907 | 60.4 | 96.5 | 3.5 | 39.6 | 95.5 | 4.5 |
| Total income | 1917 | 58.1 | 94.3 | 5.7 | 41.9 | 89.7 | 10.3 |
| | 1912 | 52.7 | 95.2 | 4.8 | 47.3 | 89.1 | 10.9 |
| | 1907 | 61.5 | 93.7 | 6.3 | 38.5 | 89.3 | 10.7 |
| Horsepower of prime movers | 1917 | 61.6 | 94.8 | 5.2 | 38.4 | 91.0 | 9.0 |
| | 1912 | 53.2 | 95.6 | 4.4 | 46.8 | 89.1 | 10.9 |
| | 1907 | 60.4 | 94.0 | 6.0 | 39.6 | 89.4 | 10.6 |
| Kilowatt capacity of dynamos | 1917 | 61.3 | 94.9 | 5.1 | 38.7 | 91.4 | 8.6 |
| | 1912 | 54.9 | 95.8 | 4.2 | 45.1 | 88.1 | 11.9 |
| | 1907 | 61.7 | 94.2 | 5.8 | 38.3 | 89.2 | 10.8 |
| Kilowatt hours generated | 1917 | 66.0 | 96.6 | 3.4 | 34.0 | 94.6 | 5.4 |
| | 1912 | 57.4 | 97.6 | 2.4 | 42.6 | 92.3 | 7.7 |
| | 1907 | 66.2 | 96.3 | 3.7 | 33.8 | 92.7 | 7.3 |
| Kilowatt hours purchased [1] | 1917 | 62.3 | 98.0 | 2.0 | 37.7 | 94.2 | 5.8 |
| | 1912 | 67.2 | 98.8 | 1.2 | 32.8 | 92.1 | 7.9 |
| Horsepower of stationary motors served | 1917 | 59.1 | 96.8 | 3.2 | 40.9 | 93.4 | 6.6 |
| | 1912 | 56.0 | 97.7 | 2.3 | 44.0 | 93.9 | 6.1 |
| | 1907 | 65.3 | 98.5 | 1.5 | 34.7 | 97.3 | 2.7 |
| Number of customers [1] | 1917 | 51.3 | 88.9 | 11.1 | 48.7 | 83.7 | 16.3 |
| | 1912 | 45.7 | 90.1 | 9.9 | 54.3 | 83.1 | 16.9 |

[1] Figures not available for 1907.

From this table it is evident that the number of purely electric stations has grown relatively greater since 1907, though the proportion which commercial stations bear to the total for this group has decreased. On the other hand, it is apparent that among the composite plants those municipally owned are forming an increasingly high proportion. So far as the different items of importance are concerned, it appears that for practically all periods the purely electric stations were relatively more important than the other group, but there has been an actual decrease in the relative importance of the former, since 1907, in the value of plant and equipment (from 60.4 to 56.6 per cent), the total income (from 61.5 to 58.1 per cent), and horsepower of stationary motors served (65.3 to 59.1 per cent). None of these decreases, however, are particularly marked, and, since the 1912 proportions are in practically every case considerably lower than those shown for 1907 or 1917, it may be that some large plants which in 1912 reported as composite carried on their businesses separately in 1917 and made a return as purely electric. Doubtless, also, plants were returned as "composite" in 1912 which should properly have been considered "purely electric." It further appears that municipal composite plants are not only more numerous but also have a relatively more important business than have the purely electric plants under the same ownership. Except in the value of plant and equipment and the horsepower of motors served, however, there has been some decrease in the relative importance of the former since 1907. In most respects commercial purely electric plants show a proportionate gain, though slight, over municipal plants in the same group since 1907.

In Table 18 is shown the average size of commercial and municipal plants, according to whether they are purely electric or composite.

**Table 18** PURELY ELECTRIC AND COMPOSITE CENTRAL ELECTRIC STATIONS—AVERAGE PER PLANT: 1917.

| | Purely electric. | | Composite. | |
|---|---|---|---|---|
| | Commercial. | Municipal. | Commercial. | Municipal. |
| Value of plant and equipment | $600,213 | $55,881 | $876,981 | $54,124 |
| Total income | $103,621 | $10,089 | $137,677 | $18,540 |
| Total number of persons employed | 19 | 4 | 28 | 5 |
| Horsepower of prime movers | 2,710 | 379 | 3,149 | 303 |
| Kilowatt capacity of dynamos | 1,870 | 260 | 2,215 | 243 |
| Kilowatt hours generated | 5,818,039 | 522,612 | 5,695,274 | 382,470 |
| Kilowatt hours purchased | 1,227,086 | 64,034 | 1,537,139 | 99,420 |
| Horsepower of stationary motors served | 1,891 | 162 | 2,450 | 203 |
| Number of customers | 1,174 | 373 | 2,039 | 464 |

From the data here given it is rather surprising to find that the value of plant and equipment per composite commercial plant ($876,981) is very much higher than that of the purely electric plant ($600,213), whereas for municipal plants the figure is somewhat lower for "composite" ($54,124) than for "purely electric" ($55,881). Further, the total income of the average commercial composite plant is about one-third larger than that of the purely electric, the number of employees is 47.4 per cent greater (28 as opposed to 19), and the average number of customers is 73.7 per cent greater (2,039 as opposed to

1,174). The number of kilowatt hours generated, however, is slightly less than in the average purely electric station, though the former has a considerable advantage in the kilowatt capacity of dynamos and the horsepower of prime movers. Some of these figures, therefore, warrant the inference that a number of the composite plants in this group found it difficult to make any accurate segregation of some of the items required by the schedule, and that consequently operations other than those of electric plants are covered. The relatively low income, as compared with the number of kilowatt hours generated by the purely electric stations, is accounted for by the fact that in this group are included practically all of those large hydroelectric plants which sell most of their current in bulk to other companies. So far as the municipal composite plants are concerned, it appears that while they produce on the average much less current than do purely electric stations in this group, yet they have an appreciably higher income and a larger number of customers. They also appear to be purchasing much more current in proportion to the total amount of business done.

*Stations purchasing all current.*—At the census of 1917 for the first time an attempt was made to show separately some of the chief items for purchasing plants. From Table 19 it appears that the number of such central stations amounts to 1,418, or 21.7 per cent of the total, whereas in 1912 the number was only 575, or 11 per cent of all stations. In the other important items this group of stations makes a far less favorable showing, and, as might be expected, since there is no investment in generating equipment, the value of plant and equipment bears a very small ratio (only 3.5 per cent) to the total value for all plants. The next lowest item is the number of kilowatt hours purchased, which forms only 4 per cent of the total output of all stations, though it amounts to 22.1 per cent of *all* purchased current. As compared with the amount of business done, these plants serve a larger number of customers, or 8.4 per cent of the total.

**Table 19** CENTRAL ELECTRIC STATIONS PURCHASING ALL CURRENT: 1917.

| | Per cent of all stations. | Total. | Commercial. | Municipal. | Average per station. | |
|---|---|---|---|---|---|---|
| | | | | | Commercial. | Municipal. |
| Number of stations | 21.7 | 1,418 | 877 | 541 | | |
| Value of plant and equipment | 3.5 | $107,968,564 | $85,350,128 | $22,618,436 | $97,321 | $41,809 |
| Income | 6.1 | $31,924,380 | $25,625,957 | $6,298,423 | $29,220 | $11,642 |
| Expenses | 6.1 | $26,124,346 | $21,159,027 | $4,965,319 | $24,127 | $9,178 |
| Kilowatt hours purchased | [1]4.0 | 1,236,670,848 | 1,074,545,276 | 162,125,572 | 1,225,251 | 299,678 |
| Number of customers | 8.4 | 602,840 | 463,189 | 139,657 | 528 | 258 |
| Number of persons employed | 5.6 | 6,875 | 4,419 | 1,456 | 5 | 3 |

[1] Per cent of total output.

The averages per plant are in several respects highly interesting. For commercial stations the average value of plant and equipment is found to be $97,321, or about one-seventh of the average for *all* commercial plants.[1] The average number of kilowatt hours purchased, 1,225,251, is about one-sixth of the average output for all commercial central stations, the average income of $29,220 is about one-fourth, while the average number of customers, 528, is more than one-third that of the total, 1,468, for this ownership group. The municipal plants, on the other hand, make a relatively much better showing, since the average value of plant and equipment is $41,809, or a little more than three-fourths that of all municipal stations ($54,950), while the average income ($11,642) and the average output of current (299,678 kilowatt hours) are about two-thirds of the average for all plants in this ownership group. The average number of customers, however, is 258, or 61.3 per cent of the total average.[1]

As compared with the average commercial purchasing stations, it appears that the average municipal station has a value of plant and equipment 43 per cent as great, receives an income equal to 39.8 per cent of the former, distributes 24.5 per cent as much current, and serves nearly half as large a body of customers. This, of course, indicates a smaller amount of business per customer and relatively much higher rates. Other aspects of these groups of plants will be discussed in another connection. (See Chapter VI.)

*Relation of central stations to population.*—While an attempt has been made for this census to show more clearly the relations existing between the population of districts served and extent of central station activity than was heretofore possible, it will be interesting first of all to make certain general comparisons with former censuses. Accordingly, Table 20 shows the relation of some of the more important items to the population in the United States at the various periods.

[1] See Table 15, p. 30.

**Table 20** CENTRAL ELECTRIC STATIONS—RELATION OF LEADING ITEMS TO POPULATION, BY GEOGRAPHIC DIVISIONS: 1917, 1912, AND 1907.

| DIVISION.[1] | Census year. | Population.[2] | Number of establishments. | | | Horsepower of prime movers. | | Kilowatt capacity of dynamos. | | Kilowatt hours generated. | | Customers. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total. | Commercial. | Municipal. | Amount. | Per 1,000 population. | Amount. | Per 1,000 population. | Amount. | Per 1,000 population. | Number. | Per 1,000 population. |
| United States | 1917 | 103,635,306 | 6,542 | 4,224 | 2,318 | 12,936,755 | 125 | 8,994,407 | 87 | 25,438,303,272 | 245,460 | 7,178,703 | 69 |
| | 1912 | 95,545,336 | 5,221 | 3,659 | 1,562 | 7,530,044 | 79 | 5,165,439 | 54 | 11,569,109,885 | 121,085 | 3,837,518 | 40 |
| | 1907 | 87,455,366 | 4,714 | 3,462 | 1,252 | 4,098,188 | 47 | 2,709,225 | 31 | 5,862,276,737 | 67,032 | 1,946,979 | 22 |
| North Atlantic | 1917 | 29,388,344 | 1,062 | 867 | 195 | 4,747,180 | 162 | 3,280,911 | 112 | 9,494,901,835 | 323,084 | 2,171,151 | 74 |
| | 1912 | 26,946,884 | 1,037 | 878 | 159 | 2,748,561 | 102 | 1,893,700 | 70 | 4,413,984,747 | 163,803 | 1,136,133 | 42 |
| | 1907 | 24,505,429 | 1,070 | 920 | 150 | 1,534,586 | 63 | 1,054,528 | 43 | 2,483,106,227 | 101,329 | 582,712 | 24 |
| South Atlantic | 1917 | 13,473,354 | 728 | 398 | 330 | 1,104,746 | 82 | 735,619 | 54 | 1,745,295,143 | 129,537 | 357,577 | 26 |
| | 1912 | 12,586,562 | 512 | 308 | 204 | 624,780 | 50 | 415,529 | 33 | 729,396,397 | 57,990 | 193,909 | 15 |
| | 1907 | 11,699,773 | 390 | 232 | 158 | 295,265 | 25 | 195,309 | 17 | 266,437,175 | 22,773 | 93,471 | 8 |
| North Central | 1917 | 32,483,936 | 3,115 | 1,788 | 1,327 | 4,011,747 | 123 | 2,869,987 | 88 | 7,533,025,658 | 231,918 | 2,944,342 | 91 |
| | 1912 | 30,683,662 | 2,337 | 1,464 | 873 | 2,292,749 | 75 | 1,608,700 | 52 | 3,240,559,539 | 105,612 | 1,477,922 | 48 |
| | 1907 | 28,883,390 | 2,095 | 1,368 | 727 | 1,219,916 | 42 | 805,012 | 28 | 1,462,114,001 | 50,621 | 722,156 | 25 |
| South Central | 1917 | 19,467,806 | 1,046 | 701 | 345 | 857,275 | 44 | 608,907 | 31 | 1,531,460,633 | 78,666 | 577,270 | 30 |
| | 1912 | 17,890,901 | 837 | 587 | 250 | 449,294 | 25 | 308,411 | 17 | 461,612,464 | 25,802 | 355,716 | 20 |
| | 1907 | 16,313,992 | 679 | 513 | 166 | 244,422 | 15 | 165,969 | 10 | 257,387,610 | 15,777 | 187,853 | 12 |
| Western | 1917 | 8,821,866 | 591 | 470 | 121 | 2,215,807 | 251 | 1,498,983 | 170 | 5,133,020,003 | 581,852 | 1,128,363 | 128 |
| | 1912 | 7,437,327 | 498 | 422 | 76 | 1,414,660 | 190 | 939,099 | 126 | 2,723,056,738 | 366,134 | 678,838 | 91 |
| | 1907 | 6,052,782 | 480 | 429 | 51 | 803,999 | 133 | 488,407 | 81 | 1,393,231,724 | 230,180 | 360,787 | 60 |

[1] See p. 18 for states composing the several geographic divisions.

[2] Bureau of the Census estimates.

It appears from this table that, notwithstanding they have by far the smallest number of stations, the states comprising the Western division not only had much the largest number of customers per 1,000 population at all periods, 128, 91, and 60, respectively, but also at the same time generated about 80 per cent more current per capita than did any other division. This division is followed in density of service by the North Central, in which only 9.1 per cent of the total population are customers, and by the North Atlantic division, in which 7.4 per cent of the inhabitants are customers. In every item indicated in the table the divisions have followed the same order at the different periods. The South Atlantic division has always had the fewest number of customers per 1,000 population, followed by the South Central; but the latter division has consistently maintained the last place in the matter of horsepower of prime movers, kilowatt capacity of dynamos, and kilowatt hours generated.

Table 21 shows for the United States as a whole the rate of increase in the per capita importance of the electric light and power industry, according to the data given in Table 20, both for the decade and for the two five-year periods 1912–1917 and 1907–1912. Accordingly, it appears that the horsepower of prime movers, the kilowatt capacity of dynamos, and the number of customers per 1,000 population increased somewhat more rapidly during the earlier period. The number of kilowatt hours generated per capita, however, increased much more rapidly between 1912 and 1917 (102.7 per cent) than during the earlier period (80.6 per cent). This, of course, indicates not only a more complete utilization of generating capacity but also a relatively larger consumption of current per customer and per capita.

**Table 21** RELATION OF LEADING ITEMS TO POPULATION—PER CENT OF INCREASE PER 1,000: 1917, 1912, AND 1907.

| | 1907–1917 | 1912–1917 | 1907–1912 |
|---|---|---|---|
| Horsepower of prime movers | 166.0 | 58.2 | 68.1 |
| Kilowatt capacity of dynamos | 180.6 | 61.1 | 74.2 |
| Kilowatt hours generated | 266.2 | 102.7 | 80.6 |
| Number of customers | 213.6 | 72.5 | 81.8 |

As at preceding census periods, an attempt has been made to show the more important statistics of municipal central electric stations, grouped according to the population of the municipalities in which they are located. As a rule, municipal plants usually serve only one locality, while commercial plants frequently extend their service to numerous adjoining municipalities, as previously suggested. Hence the number of inhabitants in the city or town where a municipal plant is located usually represents pretty closely the population of the district served. In the case of commercial plants, however, there is not necessarily any direct relation between these figures, and no attempt was made until 1917 to find out specifically the population of the territory presumably reached by central station service as opposed to the number of inhabitants in the place where such plants are located. Finally, the reader must be cautioned that in many cases municipal plants are operating in cities which are partially and often largely supplied by commercial stations. This is particularly true in the case of those publicly owned plants which do only a street-lighting business, and accordingly, in many of the larger cities the population bears no significant relation to the number of customers.

MUNICIPAL CENTRAL ELECTRIC STATIONS, BY POPULATION OF CITIES IN WHICH LOCATED AND BY GEOGRAPHIC DIVISIONS: 1917, 1912, AND 1907.

**Table 22**

| DIVISION [1] AND POPULATION GROUP. | Census year. | Number of stations. | Value of plant and equipment. | INCOME. | | | Total expenses. | Total primary horsepower. | KILOWATT CAPACITY OF DYNAMOS. | | | OUTPUT OF STATIONS (KILOWATT HOURS). | | Number of customers. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total. | Electric service. | All other sources. | | | Total. | Direct current, constant voltage and amperage. | Alternating and polyphase current. | Generated during year. | Purchased during year. | |
| Total | 1917 | 2,318 | $127,375,200 | $40,260,219 | $39,586,063 | $674,156 | $31,440,912 | 859,098 | 582,463 | 43,864 | 538,599 | 1,039,320,089 | 102,538,399 | 976,514 |
| | 1912 | 1,562 | 77,065,144 | 23,218,989 | 22,663,708 | 555,281 | 16,917,165 | 559,328 | 396,677 | 44,564 | 352,113 | 537,526,730 | 88,580,377 | 525,648 |
| | 1907 | 1,252 | 42,879,447 | 14,011,999 | 13,614,434 | 397,565 | [2] 9,167,188 | 321,351 | 209,016 | 45,993 | 163,023 | 289,462,788 | (3) | 283,825 |
| Under 5,000 | 1917 | 1,949 | 40,751,708 | 15,583,678 | 15,284,128 | 299,550 | 12,629,547 | 278,952 | 189,200 | 26,864 | 162,336 | 199,669,058 | 62,226,542 | 441,049 |
| | 1912 | 1,327 | 31,349,806 | 11,026,579 | 10,678,780 | 347,799 | 8,412,993 | 257,384 | 172,705 | 25,803 | 146,902 | 186,294,675 | 20,987,309 | 312,038 |
| | 1907 | 1,081 | 21,476,667 | 7,631,842 | 7,337,260 | 294,582 | 5,298,119 | 194,172 | 130,174 | 27,355 | 102,819 | 146,906,359 | (3) | (3) |
| 5,000 but under 25,000 | 1917 | 322 | 30,006,361 | 12,754,300 | 12,509,052 | 245,248 | 8,977,453 | 239,361 | 180,891 | 9,688 | 151,203 | 268,465,798 | 61,017,137 | 318,772 |
| | 1912 | 189 | 15,953,305 | 6,014,722 | 5,861,287 | 153,435 | 4,103,721 | 128,506 | 91,696 | 7,030 | 84,666 | 127,432,560 | 20,835,366 | 136,057 |
| | 1907 | 142 | 9,726,310 | 3,466,142 | 3,389,192 | 76,950 | 2,128,859 | 75,975 | 48,107 | 7,708 | 40,399 | 73,788,119 | (3) | (3) |
| 25,000 but under 100,000 | 1917 | 39 | 11,136,870 | 4,219,920 | 4,167,358 | 52,562 | 3,446,730 | 108,319 | 78,132 | 2,222 | 75,910 | 138,068,637 | 13,432,824 | 103,938 |
| | 1912 | 31 | 8,304,604 | 2,822,984 | 2,792,212 | 30,772 | 2,032,825 | 91,327 | 62,341 | 2,371 | 59,970 | 65,838,060 | 14,910,453 | 47,435 |
| | 1907 | 17 | 4,823,033 | 1,414,810 | 1,408,521 | 6,289 | 778,358 | 25,703 | 14,812 | 3,407 | 11,405 | 29,815,562 | (3) | (3) |
| 100,000 but under 500,000 | 1917 | 9 | 15,768,883 | 4,120,760 | 4,074,017 | 46,773 | 3,334,861 | 123,404 | 82,700 | 3,850 | 78,850 | 219,538,246 | 3,838,470 | 100,902 |
| | 1912 | 7 | 8,550,500 | 1,584,082 | 1,575,696 | 8,486 | 1,095,607 | 47,255 | 27,064 | 844 | 26,220 | 61,120,808 | 76,900 | 24,242 |
| | 1907 | 6 | 2,760,732 | 736,276 | 716,532 | 19,744 | 373,750 | 12,616 | 8,250 | 2,240 | 6,010 | 17,819,478 | (3) | (3) |
| 500,000 and over | 1917 | 8 | 29,711,378 | 3,581,531 | 3,551,508 | 30,023 | 3,052,321 | 109,062 | 71,549 | 1,240 | 70,300 | 213,578,350 | 52,023,426 | 11,853 |
| | 1912 | 8 | 12,897,868 | 1,770,622 | 1,755,833 | 14,789 | 1,272,019 | 34,856 | 42,871 | 8,516 | 34,355 | 96,840,624 | 31,770,344 | 5,876 |
| | 1907 | 6 | 4,092,735 | 762,929 | 762,929 | ..... | 588,192 | 12,825 | 7,673 | 5,283 | 2,390 | 16,133,270 | (3) | (3) |
| North Atlantic | 1917 | 195 | 13,139,670 | 5,130,524 | 5,031,228 | 99,296 | 4,246,033 | 99,149 | 66,903 | 4,594 | 62,309 | 100,379,996 | 31,835,161 | 106,993 |
| | 1912 | 159 | 9,616,877 | 3,226,157 | 3,136,497 | 89,660 | 2,475,596 | 77,698 | 54,021 | 5,055 | 48,976 | 68,625,617 | 6,864,419 | 58,219 |
| | 1907 | 153 | 7,838,995 | 2,308,082 | 2,266,506 | 41,576 | 1,436,815 | 56,580 | 35,325 | 5,503 | 29,822 | 48,861,638 | (3) | (3) |
| Under 5,000 | 1917 | 124 | 4,091,364 | 1,324,517 | 1,302,526 | 21,991 | 1,074,596 | 26,613 | 17,277 | 742 | 16,535 | 20,999,605 | 7,011,295 | 34,438 |
| | 1912 | 107 | 3,425,265 | 1,060,570 | 1,021,488 | 39,082 | 779,273 | 25,661 | 16,831 | 963 | 15,868 | 18,676,158 | 2,551,469 | 26,970 |
| | 1907 | 107 | 3,088,388 | 872,150 | 845,774 | 26,376 | 567,090 | 24,240 | 16,103 | 1,676 | 14,427 | 17,742,732 | (3) | (3) |
| 5,000 but under 25,000 | 1917 | 60 | 5,579,723 | 2,550,655 | 2,488,586 | 62,069 | 2,046,786 | 43,398 | 29,011 | 3,612 | 25,399 | 45,124,252 | 13,229,595 | 55,413 |
| | 1912 | 43 | 3,835,433 | 1,426,777 | 1,379,337 | 47,440 | 1,070,210 | 32,084 | 22,508 | 2,240 | 20,268 | 26,971,971 | 4,312,950 | 25,406 |
| | 1907 | 38 | 3,025,195 | 897,546 | 882,346 | 15,200 | 571,386 | 21,049 | 12,892 | 2,197 | 10,695 | 19,182,675 | (3) | (3) |
| 25,000 and over [4] | 1917 | 11 | 3,468,583 | 1,255,352 | 1,240,116 | 15,236 | 1,124,651 | 29,138 | 20,615 | 240 | 20,375 | 34,256,139 | 11,594,271 | 17,142 |
| | 1912 | 9 | 2,356,179 | 738,810 | 735,672 | 3,138 | 626,023 | 19,953 | 14,692 | 1,852 | 12,840 | 22,977,488 | ..... | 5,843 |
| | 1907 | 5 | 1,725,412 | 538,386 | 538,386 | ..... | 268,339 | 11,291 | 6,330 | 1,630 | 4,700 | 11,936,231 | (3) | (3) |
| South Atlantic | 1917 | 330 | 11,726,970 | 4,774,884 | 4,736,670 | 38,214 | 3,214,029 | 88,793 | 62,398 | 1,864 | 60,534 | 76,090,946 | 34,450,379 | 105,038 |
| | 1912 | 204 | 7,134,097 | 2,851,941 | 2,827,057 | 24,884 | 2,045,927 | 66,845 | 45,068 | 1,717 | 43,346 | 49,325,343 | 12,761,394 | 57,641 |
| | 1907 | 158 | 4,076,042 | 1,621,309 | 1,574,043 | 47,266 | 1,051,602 | 36,542 | 22,759 | 3,620 | 19,139 | 30,300,397 | (3) | (3) |
| Under 5,000 | 1917 | 273 | 5,425,324 | 2,117,465 | 2,098,357 | 19,108 | 1,595,746 | 33,869 | 23,356 | 1,199 | 22,166 | 22,821,335 | 17,176,622 | 49,594 |
| | 1912 | 168 | 3,626,102 | 1,351,844 | 1,341,649 | 10,195 | 1,008,405 | 29,945 | 19,934 | 994 | 18,940 | 19,220,900 | 7,728,273 | 33,767 |
| | 1907 | 142 | 2,973,002 | 1,072,023 | 1,027,220 | 44,803 | 726,425 | 25,119 | 17,349 | 1,775 | 15,574 | 18,283,131 | (3) | (3) |
| 5,000 but under 25,000 | 1917 | 53 | 3,456,777 | 1,727,915 | 1,707,909 | 19,106 | 1,022,569 | 28,374 | 19,945 | 307 | 19,638 | 24,745,909 | 17,272,101 | 40,912 |
| | 1912 | 33 | 1,512,941 | 847,744 | 833,055 | 14,689 | 496,823 | 18,600 | 12,359 | 403 | 11,956 | 13,197,804 | 5,033,121 | 17,093 |
| | 1907 | 13 | 476,510 | 230,343 | 227,880 | 2,463 | 137,415 | 4,950 | 3,183 | 568 | 2,615 | 4,563,870 | (3) | (3) |
| 25,000 and over [5] | 1917 | 4 | 2,844,869 | 930,404 | 930,404 | ..... | 595,714 | 20,550 | 19,097 | 367 | 18,730 | 28,529,702 | 1,656 | 14,532 |
| | 1912 | 3 | 1,995,054 | 652,353 | 652,353 | ..... | 540,699 | 18,300 | 12,770 | 320 | 12,450 | 16,906,639 | ..... | 6,781 |
| | 1907 | 3 | 626,530 | 318,943 | 318,943 | ..... | 187,762 | 6,473 | 2,227 | 1,277 | 950 | 7,453,396 | (3) | (3) |
| North Central | 1917 | 1,327 | 69,620,138 | 21,234,761 | 20,805,928 | 428,833 | 17,357,952 | 425,234 | 296,741 | 29,132 | 267,609 | 561,536,189 | 95,790,240 | 516,202 |
| | 1912 | 873 | 42,212,002 | 11,656,482 | 11,314,999 | 341,483 | 8,589,329 | 265,159 | 204,380 | 33,419 | 170,961 | 309,367,765 | 41,492,999 | 269,461 |
| | 1907 | 727 | 22,955,162 | 7,403,015 | 7,142,752 | 260,263 | 5,072,384 | 176,221 | 115,990 | 32,717 | 83,273 | 169,005,189 | (3) | (3) |
| Under 5,000 | 1917 | 1,154 | 22,769,603 | 9,153,018 | 8,923,228 | 229,790 | 7,578,615 | 156,686 | 107,803 | 21,849 | 85,954 | 118,023,479 | 26,436,960 | 272,469 |
| | 1912 | 762 | 16,625,643 | 6,099,894 | 5,872,939 | 226,955 | 4,695,449 | 141,037 | 95,263 | 20,584 | 75,679 | 107,842,471 | 4,172,647 | 183,716 |
| | 1907 | 636 | 11,306,559 | 4,178,706 | 3,992,505 | 186,201 | 2,999,451 | 110,320 | 73,973 | 20,864 | 53,109 | 81,262,275 | (3) | (3) |
| 5,000 but under 25,000 | 1917 | 143 | 13,746,276 | 5,804,156 | 5,691,004 | 113,152 | 4,210,939 | 118,371 | 79,418 | 4,428 | 74,990 | 138,225,325 | 16,082,944 | 159,136 |
| | 1912 | 86 | 7,849,799 | 2,727,047 | 2,652,500 | 74,547 | 1,836,670 | 58,042 | 43,628 | 3,466 | 40,162 | 64,338,060 | 5,515,435 | 69,133 |
| | 1907 | 76 | 4,828,705 | 1,820,198 | 1,775,195 | 54,003 | 1,127,782 | 40,166 | 26,042 | 4,383 | 21,659 | 43,623,083 | (3) | (3) |
| 25,000 but under 100,000 | 1917 | 20 | 5,770,583 | 2,123,467 | 2,093,637 | 29,830 | 1,706,543 | 59,761 | 43,080 | 1,165 | 41,915 | 80,407,425 | 1,702,670 | 61,103 |
| | 1912 | 15 | 2,445,701 | 736,946 | 715,438 | 21,508 | 503,821 | 19,545 | 13,505 | 890 | 12,615 | 20,359,104 | 34,573 | 10,636 |
| | 1907 | 6 | 665,888 | 200,438 | 200,123 | 315 | 136,986 | 3,875 | 2,735 | 1,380 | 1,355 | 5,521,786 | (3) | (3) |
| 100,000 but under 500,000 | 1917 | 3 | 4,703,609 | 1,154,446 | 1,128,300 | 26,146 | 1,197,210 | 28,154 | 20,500 | 700 | 19,800 | 71,039,410 | ..... | 21,205 |
| | 1912 | 3 | 2,976,238 | 447,667 | 443,983 | 3,684 | 411,328 | 14,575 | 10,054 | 654 | 9,400 | 21,534,962 | ..... | 100 |
| | 1907 | 5 | 2,177,490 | 472,801 | 453,057 | 19,744 | 280,168 | 9,720 | 6,037 | 1,277 | 4,760 | 13,487,582 | (3) | (3) |
| 500,000 and over | 1917 | 7 | 22,630,062 | 2,999,674 | 2,969,759 | 29,915 | 2,664,595 | 62,262 | 45,940 | 990 | 44,950 | 153,640,550 | 51,567,666 | 2,289 |
| | 1912 | 7 | 12,314,621 | 1,644,928 | 1,630,139 | 14,789 | 1,142,061 | 31,960 | 40,930 | 7,825 | 33,105 | 94,793,168 | 31,770,344 | 5,876 |
| | 1907 | 4 | 3,976,520 | 721,872 | 721,872 | ..... | 547,997 | 12,140 | 7,203 | 4,813 | 2,390 | 15,105,460 | (3) | (3) |

[1] See p. 18 for states composing the several geographic divisions.
[2] Exclusive of interest on bonds, etc.
[3] Figures not available.
[4] Includes in 1917, 1 station of the "100,000 but under 500,000" group; in 1912, 1 station of the "500,000 and over" group; and in 1907, 1 station of the "100,000 but under 500,000" group and 1 station of the "500,000 and over" group, in order that the operations of individual stations may not be disclosed.
[5] Includes in 1917, 2 stations of the "100,000 but under 500,000" group; in 1912, 1 station of the "100,000 but under 500,000" group; and in 1907, 1 station of the "500,000 and over" group.

MUNICIPAL CENTRAL ELECTRIC STATIONS, BY POPULATION OF CITIES IN WHICH LOCATED AND BY GEOGRAPHIC DIVISIONS: 1917, 1912, AND 1907—Continued.

**Table 22**—Continued.

| DIVISION[1] AND POPULATION GROUP. | Census year. | Number of stations. | Value of plant and equipment. | INCOME. | | | Total expenses. | Total primary horsepower. | KILOWATT CAPACITY OF DYNAMOS. | | | OUTPUT OF STATIONS (KILOWATT HOURS). | | Number of customers. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total. | Electric service. | All other sources. | | | Total. | Direct current, constant voltage and amperage. | Alternating and polyphase current. | Generated during year. | Purchased during year. | |
| SOUTH CENTRAL | 1917 | 345 | $11,908,817 | $4,334,193 | $4,302,201 | $31,992 | $3,187,695 | 88,649 | 60,332 | 4,782 | 55,550 | 77,388,030 | 5,988,978 | 100,766 |
| | 1912 | 250 | 8,256,749 | 2,870,011 | 2,831,077 | 38,934 | 2,080,541 | 67,576 | 44,645 | 4,146 | 40,499 | 54,562,006 | 1,773,653 | 60,785 |
| | 1907 | 166 | 4,259,121 | 1,640,608 | 1,609,032 | 31,576 | 1,070,069 | 36,440 | 25,133 | 3,840 | 21,293 | 34,365,978 | (2) | (2) |
| Under 5,000 | 1917 | 289 | 5,983,580 | 2,071,421 | 2,061,116 | 10,305 | 1,690,905 | 44,781 | 30,100 | 2,891 | 27,209 | 26,093,065 | 1,656,466 | 56,794 |
| | 1912 | 223 | 5,364,162 | 1,740,004 | 1,706,105 | 33,899 | 1,392,422 | 44,271 | 29,784 | 3,035 | 26,749 | 28,687,220 | 654,403 | 44,961 |
| | 1907 | 152 | 3,046,244 | 1,133,925 | 1,104,549 | 29,376 | 788,196 | 27,510 | 18,415 | 2,772 | 15,643 | 23,272,368 | (2) | (2) |
| 5,000 but under 25,000 | 1917 | 50 | 4,462,390 | 1,775,543 | 1,753,856 | 21,687 | 1,096,281 | 36,118 | 24,382 | 1,291 | 23,091 | 40,952,255 | 1,547,634 | 37,772 |
| | 1912 | 21 | 1,513,443 | 606,193 | 601,158 | 5,035 | 437,880 | 14,010 | 9,536 | 921 | 8,615 | 15,395,262 | 2,500 | 12,243 |
| | 1907 | 10 | 705,552 | 321,549 | 319,349 | 2,200 | 182,060 | 5,625 | 3,815 | 515 | 3,300 | 6,861,650 | (2) | (2) |
| 25,000 and over[3] | 1917 | 6 | 1,462,847 | 487,229 | 487,229 | ..... | 400,509 | 7,750 | 5,850 | 600 | 5,250 | 10,342,710 | 2,784,878 | 6,200 |
| | 1912 | 6 | 1,379,144 | 523,814 | 523,814 | ..... | 250,239 | 9,295 | 5,325 | 190 | 5,135 | 10,479,524 | 1,116,750 | 3,581 |
| | 1907 | 4 | 507,325 | 185,134 | 185,134 | ..... | 99,813 | 3,305 | 2,903 | 553 | 2,350 | 4,231,960 | (2) | (2) |
| WESTERN | 1917 | 121 | 20,979,605 | 4,785,857 | 4,710,036 | 75,821 | 3,435,203 | 157,273 | 96,089 | 3,492 | 92,597 | 224,118,928 | 24,473,641 | 147,515 |
| | 1912 | 76 | 9,845,419 | 2,614,398 | 2,554,078 | 60,320 | 1,725,862 | 82,050 | 48,558 | 227 | 48,331 | 55,645,999 | 25,687,912 | 79,542 |
| | 1907 | 51 | 3,750,127 | 1,038,985 | 1,022,101 | 16,884 | 566,318 | 15,568 | 9,809 | 313 | 9,496 | 16,929,586 | (2) | (2) |
| Under 5,000 | 1917 | 100 | 2,481,832 | 917,257 | 898,901 | 18,356 | 689,685 | 17,003 | 10,664 | 192 | 10,472 | 11,731,574 | 9,945,199 | 27,764 |
| | 1912 | 67 | 2,308,634 | 774,267 | 736,599 | 37,668 | 537,444 | 16,470 | 9,893 | 227 | 9,666 | 11,867,929 | 5,880,517 | 22,624 |
| | 1907 | 44 | 1,062,474 | 375,038 | 367,212 | 7,826 | 216,957 | 6,983 | 4,334 | 268 | 4,066 | 6,345,853 | (2) | (2) |
| 5,000 and over[4] | 1917 | 21 | 18,497,773 | 3,868,600 | 3,811,135 | 57,465 | 2,745,518 | 140,270 | 85,425 | 3,300 | 82,125 | 212,387,354 | 14,528,442 | 119,761 |
| | 1912 | 9 | 7,536,785 | 1,840,131 | 1,817,479 | 22,652 | 1,188,418 | 65,580 | 38,665 | ..... | 38,665 | 43,778,070 | 19,807,395 | 56,918 |
| | 1907 | 7 | 2,687,653 | 663,947 | 654,889 | 9,058 | 349,361 | 8,585 | 5,475 | 45 | 5,430 | 10,583,733 | (2) | (2) |

[1] See p. 18 for states composing the several geographic divisions.
[2] Figures not available.
[3] Includes in 1917, 1 station of the "100,000 but under 500,000" group; and in 1912, 2 stations of the "100,000 but under 500,000" group.
[4] Includes in 1917, 1 station of the "25,000 but under 100,000" group, 2 stations of the "100,000 but under 500,000" group, and 1 station of the "500,000 and over" group; in 1912, 2 stations of the "25,000 but under 100,000" group and 1 station of the "100,000 but under 500,000" group; and in 1907, 2 stations of the "25,000 but under 100,000 group."

In Table 22 municipal stations are grouped according to the population of cities in which located, for the years 1917, 1912, and 1907. For each group, also, is shown not only the "value of plant and equipment," but also the "total income," "total expenses," "total primary horsepower," "total kilowatt capacity of dynamos," "output of stations," and "number of customers." From this table it is evident that there has been no marked change in the number of stations located in places having a population of 25,000 and over. The most rapid increase from 1912 to 1917 has been in the population group between 5,000 and 25,000, or about 70 per cent. The group of stations in places having less than 5,000 population is by far the most numerous (1,940 out of a total of 2,318), but the rate of increase in this group has been only 46.2 per cent during the last five years. In the "value of plant and equipment" the rate of increase has been most rapid in the "500,000 and over" group, due primarily to the installation of the large Los Angeles plant and to the extension of already existing plants in Chicago. This group, both in absolute amount and in percentage of increase, has been followed by those plants in places having 5,000 but under 25,000 population. The former group, while leading in the rate of increase in "value of plant and equipment," has been surpassed in most other respects by the small group found in places having from 100,000 to 500,000 population. This more rapid growth is almost solely accounted for by the large municipal station installed in the city of Cleveland and serving a portion of its population.

Table 23 shows for the plants grouped in Table 22 the relative importance of the different items for the year 1917.

**Table 23**

MUNICIPAL CENTRAL ELECTRIC STATIONS—PER CENT DISTRIBUTION ACCORDING TO POPULATION OF MUNICIPALITIES IN WHICH LOCATED: 1917.

| | Under 5,000. | 5,000 but under 25,000. | 25,000 but under 100,000. | 100,000 but under 500,000. | 500,000 and over. |
|---|---|---|---|---|---|
| Number of stations | 83.7 | 13.9 | 1.7 | 0.4 | 0.3 |
| Value of plant and equipment | 32.0 | 23.6 | 8.7 | 12.4 | 23.3 |
| Total income | 38.7 | 31.7 | 10.5 | 10.2 | 8.9 |
| Total expenses | 40.2 | 28.5 | 11.0 | 10.6 | 9.7 |
| Horsepower of prime movers | 32.5 | 27.8 | 12.6 | 14.4 | 12.7 |
| Kilowatt capacity of dynamos | 32.5 | 27.6 | 13.4 | 14.2 | 12.3 |
| Kilowatt hours generated | 19.2 | 25.8 | 13.3 | 21.1 | 20.6 |
| Kilowatt hours purchased | 32.3 | 31.7 | 7.0 | 2.0 | 27.0 |
| Number of customers | 45.2 | 32.7 | 10.6 | 10.3 | 1.2 |

From this table it appears that 83.7 per cent of all municipal plants are in places having less than 5,000 population, and in all other respects, except in the number of kilowatt hours generated, this group shows the highest proportions—32 per cent of the value of plant and equipment, 38.7 per cent of the total income, 40.2 per cent of the total expenses, 32.5 per cent of the horsepower of prime movers, 32.5 per cent of the kilowatt capacity of dynamos, 32.3 per cent of the kilowatt hours purchased, and 45.2 per cent of the number of customers. Upon comparison with 1912, however, it appears that there has been a considerable decrease in the importance of this group as compared with the higher population groups. In that year stations in places having less than 5,000 population comprised 85 per cent of the total number reporting, 40.7 per cent of the value of plant and equipment, 47.5 per cent of the total income, 46 per cent of the primary power, and 43.5 per cent of the kilowatt capacity of dynamos, and generated 34.7 per cent of all current, as opposed to only 19.2 per cent in 1917. The value of plant and equipment is practically the same in the "5,000 but under 25,000" group and in the "500,000 and over" group. In all other respects, however, the former group is markedly in the lead. The comparative importance of the various items is not much different in the "25,000 but under 100,000" group and the "100,000 but under 500,000" group, except in the number of stations and in the number of kilowatt hours purchased, in which the former has a marked advantage, while the latter shows a greater value of plant and equipment (12.4 per cent of the total as opposed to 9 per cent) and generated a far larger proportion of current (21.1 per cent of the total as opposed to 13.7 per cent). Relative to the amount of investment, the number of customers is decidedly lower in the larger population groups, due to the fact that these plants, in the main, do only a street-lighting business.

*All stations grouped according to the population of districts served: 1917.*—It was thought desirable for the present census to secure, if possible, more complete data than have ever yet been assembled regarding the population of the territory actually served by all central electric stations in the United States, as contrasted with the population of municipalities in which central stations are located. To be sure, absolutely accurate figures on this subject are in some instances practically impossible to obtain, because of the nature of the service rendered and the character of territory served. It frequently happens, also, that an electric light and power plant will serve a population which in the summer is far in excess of the normal winter population. In such cases it is naturally difficult to determine what is the true population served, and the Census Bureau, in the absence of more specific information, has usually accepted the average of the summer and winter population as being a reasonable estimate of the number of inhabitants in the district served with electricity by a given station. Attention should further be called to the fact that frequently a number of commercial stations are serving the same population group, while it also happens in many cases that municipal and commercial plants do business in the same territory. Hence, in combining the number of inhabitants served by the two groups of plants, great care had to be exercised in order to eliminate duplicated population. Finally, while every effort has been made, by means of correspondence and by the use of the most recent figures on population, to check up all the schedule returns in answer to this inquiry, there yet remains a slight possibility of error, due to the fact that the actual population of many municipalities can not always be accurately ascertained. Some, particularly in the industrial sections, have during the past few years grown with unwonted rapidity, while it is probable that others have actually lost a portion of their population since the last official census was taken in 1910. It is felt, however, that any of the errors which may have crept into these figures will largely counterbalance each other, so that the public may be assured that the percentage of error in the following tables has been reduced almost to the vanishing point.

In Table 24 an attempt has been made to show the amount of current sold for light and power by all central electric stations in the United States, grouped into 10 classes according to the population of the districts actually served from a given center. It should be remembered that the population reported is not necessarily included within the bounds of any one municipality. In a few instances it comprises only that portion of such population which a central station is in a position to serve, but in very numerous cases the number of people who live within the territory reached by the service lines of an electric station comprise the aggregate population of many separate municipalities, together with an uncertain number of suburban residents.

**Table 24** CENTRAL ELECTRIC STATIONS, GROUPED ACCORDING TO POPULATION OF DISTRICTS SERVED, TOGETHER WITH THE NUMBER OF KILOWATT HOURS CONSUMED FOR LIGHT AND POWER SERVICE: 1917.

| POPULATION GROUP. | Number of stations. | Population of districts served. | Kilowatt hours consumed for light. | Kilowatt hours consumed for power. | Per cent distribution. | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Number. | Population. | Kilowatt-hour consumption. | |
| | | | | | | | Light. | Power. |
| Total | 6,489 | 62,919,662 | 5,112,412,249 | 12,586,028,828 | 100.0 | 100.0 | 100.0 | 100.0 |
| Under 1,000 | 2,221 | 1,185,760 | 52,083,623 | 269,892,135 | 34.2 | 1.9 | 1.0 | 2.1 |
| 1,000 but under 2,000 | 1,455 | 1,841,370 | 94,610,077 | 202,227,849 | 22.4 | 2.9 | 1.9 | 1.6 |
| 2,000 but under 5,000 | 1,363 | 3,740,683 | 218,893,205 | 354,403,358 | 21.0 | 5.9 | 4.3 | 2.8 |
| 5,000 but under 10,000 | 576 | 3,366,579 | 226,054,802 | 361,796,574 | 8.9 | 5.4 | 4.4 | 2.9 |
| 10,000 but under 25,000 | 408 | 5,111,742 | 346,885,079 | 1,332,081,698 | 6.3 | 8.1 | 6.8 | 10.6 |
| 25,000 but under 50,000 | 181 | 4,724,429 | 349,085,990 | 946,339,029 | 2.8 | 7.5 | 6.8 | 7.5 |
| 50,000 but under 100,000 | 100 | 4,731,522 | 345,429,519 | 1,270,413,675 | 1.5 | 7.5 | 6.8 | 10.1 |
| 100,000 but under 200,000 | 69 | 7,182,363 | 460,182,514 | 1,304,131,792 | 1.1 | 11.4 | 9.0 | 10.4 |
| 200,000 but under 500,000 | 51 | 9,935,508 | 811,360,518 | 2,134,976,626 | 0.8 | 15.8 | 15.9 | 17.0 |
| 500,000 and over | 65 | 21,099,706 | 2,207,826,862 | 4,409,766,092 | 1.0 | 33.5 | 43.2 | 35.0 |
| Commercial | 4,171 | 56,459,723 | 4,445,113,085 | 12,244,302,657 | 100.0 | 100.0 | 100.0 | 100.0 |
| Under 1,000 | 1,477 | 770,988 | 32,328,817 | 266,683,786 | 35.4 | 1.4 | 0.7 | 2.2 |
| 1,000 but under 2,000 | 830 | 1,061,322 | 52,154,089 | 191,390,836 | 19.9 | 1.9 | 1.2 | 1.6 |
| 2,000 but under 5,000 | 792 | 2,234,221 | 124,282,038 | 311,526,747 | 19.0 | 4.0 | 2.8 | 2.5 |
| 5,000 but under 10,000 | 352 | 2,176,865 | 130,301,018 | 316,354,394 | 8.4 | 3.9 | 2.9 | 2.6 |
| 10,000 but under 25,000 | 310 | 4,287,745 | 270,081,527 | 1,282,679,204 | 7.4 | 7.6 | 6.1 | 10.5 |
| 25,000 but under 50,000 | 154 | 4,323,114 | 307,636,232 | 922,898,973 | 3.7 | 7.7 | 6.9 | 7.5 |
| 50,000 but under 100,000 | 88 | 4,500,810 | 313,270,631 | 1,239,120,418 | 2.1 | 8.0 | 7.0 | 10.1 |
| 100,000 but under 200,000 | 63 | 6,669,430 | 420,866,425 | 1,271,658,136 | 1.5 | 11.8 | 9.5 | 10.4 |
| 200,000 but under 500,000 | 48 | 9,335,522 | 760,656,274 | 2,092,549,543 | 1.2 | 16.5 | 16.8 | 17.1 |
| 500,000 and over | 57 | 21,099,706 | 2,040,844,854 | 4,349,530,020 | 1.4 | 37.3 | 45.9 | 35.5 |
| Municipal | 2,318 | 13,671,460 | 667,299,164 | 341,636,171 | 100.0 | 100.0 | 100.0 | 100.0 |
| Under 1,000 | 744 | 423,786 | 19,754,806 | 3,208,349 | 32.1 | 3.1 | 3.0 | 0.9 |
| 1,000 but under 2,000 | 625 | 822,597 | 42,455,988 | 10,837,013 | 27.0 | 6.0 | 6.4 | 3.2 |
| 2,000 but under 5,000 | 571 | 1,043,319 | 94,610,567 | 42,876,611 | 24.6 | 12.0 | 14.2 | 12.5 |
| 5,000 but under 10,000 | 224 | 1,415,297 | 95,968,244 | 45,442,180 | 9.7 | 10.4 | 14.3 | 13.3 |
| 10,000 but under 25,000 | 98 | 1,344,354 | 70,203,552 | 49,402,494 | 4.2 | 9.8 | 11.4 | 14.5 |
| 25,000 but under 50,000 | 27 | 934,460 | 41,449,758 | 23,440,056 | 1.2 | 6.8 | 6.2 | 6.9 |
| 50,000 but under 100,000 | 12 | 713,191 | 32,158,888 | 31,263,257 | 0.5 | 5.2 | 4.8 | 9.2 |
| 100,000 but under 200,000 | 6 | 775,216 | 33,316,089 | 32,473,056 | 0.3 | 5.7 | 5.0 | 9.5 |
| 200,000 but under 500,000 | 3 | 850,000 | 64,704,244 | 42,427,083 | 0.1 | 6.2 | 9.7 | 12.4 |
| 500,000 and over | 8 | 4,748,940 | 166,982,028 | 60,235,472 | 0.3 | 34.7 | 25.0 | 17.6 |

It must be explained also that the discrepancy between the number of stations recorded in this table, 6,489, and the total number of stations in the United States, 6,542, is occasioned because of the fact that 42 commercial stations in 1917 sold current only to other companies, and so could not properly be said to serve any population. There were 11 other stations, 10 of which sold some current for power, while 1 sold a small amount for lighting purposes, but it was impossible to ascertain any population for the districts which theoretically they served, due to the fact that this current was supplied almost solely to large and widely scattered manufacturing concerns, while the plants themselves were located in rural sections. The total number of these plants, 53, together with their output for light (104,700 kilowatt hours) and power (588,798,449 kilowatt hours), added to the figures appearing in Table 24 will give the United States totals as recorded in earlier tables.

In the case of both commercial and municipal stations it is almost astounding to find how large a number serve so minute a population—about a third of each group (35.4 per cent for commercial and 32.1 per cent for municipal) serve less than 1,000 inhabitants—and, as it will be shown in a later chapter,[1] the average population served by plants in these groups is a little more than 500, though somewhat larger for municipal than for commercial plants. In both groups considerably more than half of all stations (55.3 per cent of commercial stations and 59 per cent of municipal) are to be found serving a population under 2,000 and averaging little more than 800. In percentage distribution there is a constant increase in the number of inhabitants served by commercial stations, from the smallest population group to the largest. For municipal plants, however, while the group serving "500,000 and over" supplies 34.7 per cent of the entire population reached by all municipal stations, yet, aside from this instance, the highest amount of population, relatively, is to be found in those three groups ranging between 2,000 and 25,000.

The amount of duplicated population which has been eliminated in securing the aggregate figures for the United States is 7,211,521. In this connection it may be interesting to note that all of the population served by municipal plants in the highest group, 4,748,940, is also served by commercial plants. In fact, the publicly owned plants in this territory confine themselves almost solely to a street-lighting and municipal power business. Nor must it be inferred that there are 8 different municipal plants in separate cities having a population in excess of 500,000. Five

[1] See Table 58, p. 84.

of these plants are in the city of Chicago, while the other 3 are located in Los Angeles, St. Louis, and Detroit. The municipal plant in the city of Cleveland serves only a portion of the entire population and has been reported in the population group between 200,000 and 500,000, along with the Columbus and Seattle plants.

Finally, it is significant to find that 8 of the North Central states—Nebraska, Iowa, Kansas, Wisconsin, Missouri, Illinois, Minnesota, and Ohio, in the order given—all report more than 100 plants in the lowest population group, or an aggregate of 1,090, which is almost 50 per cent of the total number of plants in this group. The same states, also, with the addition of New York, Michigan, and Georgia, report almost half of the total number of plants in the population group between 1,000 and 2,000, while in many cases, with the addition of Pennsylvania and Oklahoma, they also lead in the number of stations reported in the population group between 2,000 and 5,000. These figures are interesting when considered along with the distribution, according to states, of plants purchasing all their current, as well as of those smaller unincorporated stations which generated current largely by the use of internal-combustion engines for primary power. The former are most numerous in the states of Iowa, Ohio, New York, Pennsylvania, Indiana, Illinois, Kansas, Massachusetts, Wisconsin, and Minnesota, in the order given, all of which report more than 50 purchasing plants per state, making a total of 792, or 55.9 per cent of all such plants in the United States. As it has been already pointed out, in addition to the state of Texas the individual plants and firms are also found in greatest numbers in Minnesota, Iowa, Missouri, Nebraska, Kansas, North Dakota, Ohio, Illinois, Michigan, and New York.

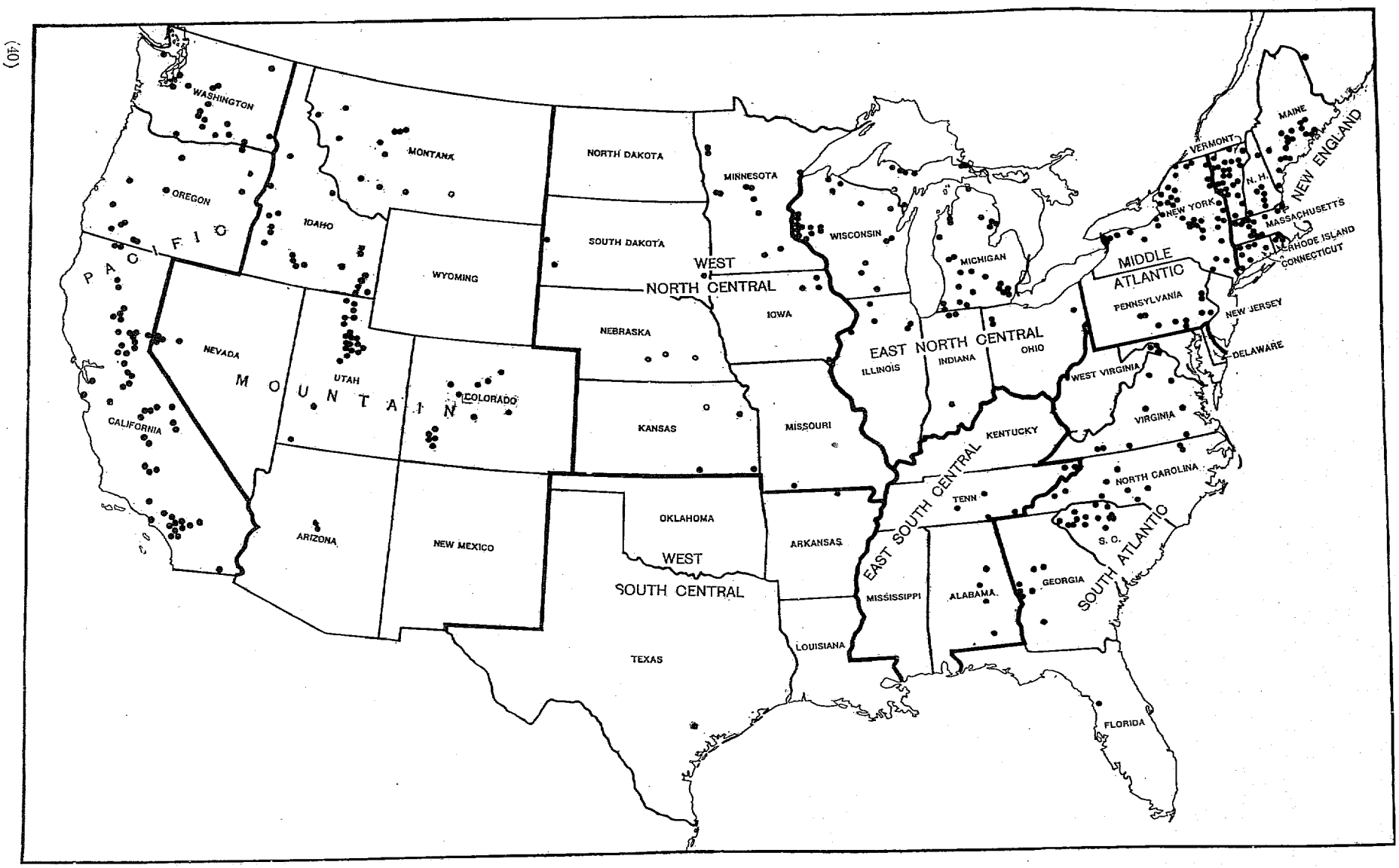
Perhaps little need be said at this stage regarding the relative quantity of current supplied for light and for power by the various groups of plants, as the matter will be more carefully analyzed in the chapter on "Output and disposal of current." Attention should, however, be called to the fact that, with one exception, the different groups of commercial plants show an increase in the percentage distribution of current supplied both for light and power almost in equal ratio with the increase in the percentage distribution of population. The quantity of current supplied for light by the group of stations supplying a population in excess of 500,000 (45.9 per cent of the total for commercial plants) is relatively higher than the quantity supplied for power (35.5 per cent). This is readily accounted for by the fact that the population of districts served does not necessarily bear close relation to the amount of current which may be utilized for power purposes. On the contrary, it is the location of large factories and mines which is the most decisive factor in the situation, whereas current will not be supplied for lighting to an increasing extent unless the population is also increased. The percentages for municipal plants disclose a different condition. While it is true that the highest population group delivers the greatest relative quantity of current both for light and power (25 per cent and 17.6 per cent, respectively), yet, aside from this case, the highest percentage distribution is to be found in those groups of municipal plants between 2,000 and 25,000 population, all 3 of which are reasonably close together. Those municipal plants serving a population between 200,000 and 500,000 rank fifth in distribution of current.

**Table 25** COMMERCIAL AND MUNICIPAL CENTRAL ELECTRIC STATIONS GROUPED ACCORDING TO POPULATION OF DISTRICTS SERVED—PER CENT OF TOTAL NUMBER AND OUTPUT FOR LIGHT AND FOR POWER: 1917.

| POPULATION GROUP. | Number. | | Kilowatt hours consumed for light. | | Kilowatt hours consumed for power. | |
|---|---|---|---|---|---|---|
| | Commercial. | Municipal. | Commercial. | Municipal. | Commercial. | Municipal. |
| Under 1,000 | 66.5 | 33.5 | 62.1 | 37.9 | 98.8 | 1.2 |
| 1,000 but under 2,000 | 57.0 | 43.0 | 55.1 | 44.9 | 94.6 | 5.4 |
| 2,000 but under 5,000 | 58.1 | 41.9 | 56.8 | 43.2 | 87.9 | 12.1 |
| 5,000 but under 10,000 | 61.1 | 38.9 | 57.7 | 42.3 | 87.4 | 12.6 |
| 10,000 but under 25,000 | 76.0 | 24.0 | 78.0 | 22.0 | 96.3 | 3.7 |
| 25,000 but under 50,000 | 85.1 | 14.9 | 88.1 | 11.9 | 97.5 | 2.5 |
| 50,000 but under 100,000 | 88.0 | 12.0 | 90.7 | 9.3 | 97.5 | 2.5 |
| 100,000 but under 200,000 | 91.3 | 8.7 | 92.8 | 7.2 | 97.5 | 2.5 |
| 200,000 but under 500,000 | 94.1 | 5.9 | 92.0 | 8.0 | 98.0 | 2.0 |
| 500,000 and over | 87.7 | 12.3 | 92.4 | 7.6 | 98.6 | 1.4 |

Perhaps it will be of interest further to indicate the relative importance of commercial and municipal stations according to the per cent of the total number and output which each class forms of the several population groups. From Table 25 it can be seen that municipal plants are relatively most numerous (43 per cent of the total) in that group serving a population between 1,000 and 2,000. The percentage of municipal plants is almost as high in the next two groups, 41.9 and 38.9 per cent. From this point there is a gradual decrease in relative number of municipal plants until the highest group is reached, in which the percentage is abnormally high (12.3) because of the fact that the 5 municipal plants in the city of Chicago are serving the same population. Contrary to what might have been expected, municipal plants form a lower per cent of the total number found in the population group "under 1,000" (33.5 per cent) than in the three succeeding groups. In the sales of current for lighting purposes the municipal plants report the highest percentage of the total in the four lowest groups, with an almost uninterrupted decrease in relative importance as the higher groups are reached. The same general conditions prevail so far as current supplied for power is concerned, though in all but two cases the relative quantity of such current reported by municipalities is negligible in every group.

MAP 2.—LOCATION OF HYDROELECTRIC CENTRAL STATIONS REPORTING WATER POWER OF 1,000 HORSEPOWER OR MORE, BY GEOGRAPHIC DIVISIONS: 1917.



# CHAPTER III.—DEVELOPMENT OF HYDROELECTRIC STATIONS.

*Hydroelectric development.*—As the cost of fuel mounts, increasing attention is being directed to the possibility of a further extension of hydroelectric development in the United States.

In the movement for fuel conservation, through the increased utilization of water power and the use of electricity thus generated for industrial purposes in place of the present wasteful methods of supplying motive power, the states and the Federal Government have taken a profound interest. Estimates vary widely as to the actual amount of water power which would at all times be available for the generation of electricity, and at present there are many sections of the country which could not in any event be supplied with current produced in water-power plants, owing to the natural limits to long-distance transmission. The official estimates made in 1912 place the minimum horsepower of our waterways at 27,000,000 during the most unfavorable periods, the maximum being at least 52,000,000.[1] Some estimates have placed the maximum at not less than 60,000,000, and, beyond a doubt, many times the minimum horsepower here mentioned could be secured through artificial develcpment, such as the construction of storage basins, etc. According to the census figures for 1914, 1,826,443 water horsepower was used in manufacturing industries;[2] and the present census of electrical industries discloses the fact that in addition central electric stations and street railways together utilize 4,905,256 water horsepower. This would indicate a total developed water horsepower at the present time of not far from 7,000,000, since there are numerous private developments which have not been included in the census returns. Hence there is apparently left, under the most unfavorable conditions, at least 20,000,000 undeveloped water horsepower, an amount which could be vastly increased by artificial measures. In 1917 the electrical industries under consideration reported 11,992,991 steam horsepower and 238,700 horsepower in internal-combustion engines, while the latest figures available show 15,681,688 steam horsepower used in manufacturing industries, together with 991,905 in internal-combustion engines. Accordingly, the total horsepower, other than water wheels and turbines used in all industries and electric public utilities, is probably at present not far from 30,000,000. Steam heating plants will, in addition, utilize many million more boiler horsepower, and the 60,000 odd locomotive engines in the United States[3] doubtless represent in the aggregate a steam horsepower even greater than that used in industries and local public utilities.

[1] Report of the Commissioner of Corporations on Water-power Development in the United States, 1912.
[2] Statistical Abstract of the Census of Manufactures, 1914, p. 491.
[3] Statistical Abstract, 1916, p. 294.

It is no doubt true that a large part of the motive power which is at present supplied by the wasteful combustion of coal and the utilization of gas and oil can be, and eventually will be, obtained through the generation of electric current by means of nature's unfailing water supply. Buildings may thus be heated by electricity, and a large per cent of our steam railways might profitably be electrified. As our resources of coal and oil become exhausted, with the attendant prohibitive rise in prices, hydroelectric development will increase with rapid strides. It must not be forgotten, however, that the distance over which electricity can profitably be transmitted, which is now not less than 250 miles, is still strictly limited by engineering difficulties. Hence there will always be sections which can not be served by hydroelectric development. Further, the capital outlays required for the development of storage facilities as well as for the installation of generating stations sufficiently large for economic operations, not to mention the enormous cost of constructing and maintaining high-tension transmission lines, act in the present as a strong deterrent from the rapid growth of hydroelectric generation and transmission of current. Again, if our water power were developed to its highest utilization it would naturally be accompanied by the abandonment of a large number of the central stations now in operation, together with the junking of a large part of the equipment at present used in manufacturing establishments. To be sure, there would be a saving in fuel which at present prices would amount to from $1,000,000,000 to $2,000,000,000 annually. There would be a further saving of at least hundreds of millions of dollars which are now paid as wages to the many thousands of workers whose services are rendered necessary by the present methods of supplying power, but whose services would no longer be necessary with a general electrification of industries. All of these prospective savings appeal to the imagination of one who studies the future problems of industry. At present, however, the high cost of copper and of capital needed for the developmental purposes is rather effectively offsetting the high cost of fuel used in the old establishments.

In many cases it appears to be true that the gains which would result from a conservation of the national fuel supply and a full utilization of the national water resources would be "public and future" rather than "private and present." What from an engineering point of view may be possible is not necessarily advantageous. Hence, though there is sufficient water power in the New England states and in New York, Pennsylvania, West Virginia, and the Carolinas to supply most of the industries in the United States, and while there are still vast resources in the mountains of the West which would make it

possible to electrify an extensive mileage of the transcontinental railways, and though many buildings and private residences might be heated by means of electric current, yet the development under private control will be gradual, until the time is reached when the economic and social gains generally resulting from conservation of this sort will outweigh the costs which such a change would unavoidably entail. With lower interest rates, with lower prices for material and labor, together with greater certainty of return on legitimate investment than at present exists, the movement in this direction would doubtless be more rapid. At any rate it may reasonably be expected that in the future, wherever possible without the actual destruction of existing investments, water power will be more widely used.

*Importance of hydroelectric stations.*—With a view to showing the relative importance of those larger water-power plants to which the term "hydroelectric" is more properly applied, Table 26 has been prepared. In this tabulation are given, for 1917 and 1912, the leading items for all stations in the United States, together with corresponding items for those stations which report water-power equipment of 1,000 horsepower and over. Some of these, of course, use other kinds of primary power.

**Table 26** CENTRAL ELECTRIC STATIONS—COMPARISON OF HYDROELECTRIC AND ALL STATIONS: 1917 AND 1912.

| | 1917 | | 1912 | | Hydroelectric stations—Per cent of total. | | Per cent of increase.[1] | |
|---|---|---|---|---|---|---|---|---|
| | All stations. | Stations reporting water power of 1,000 horsepower and over. | All stations. | Stations reporting water power of 1,000 horsepower and over. | 1917 | 1912 | All stations. | Hydroelectric stations. |
| Number of stations | 6,542 | 259 | 5,221 | 225 | 4.0 | 4.3 | 25.3 | 15.1 |
| Value of plant and equipment | $3,060,392,141 | $1,396,619,224 | $2,175,678,266 | $922,954,341 | 45.6 | 42.2 | 40.7 | 51.3 |
| Total income | $526,894,240 | $157,580,682 | $302,273,398 | $72,717,582 | 29.9 | 24.1 | 74.3 | 116.7 |
| Electric service | $502,059,980 | $149,224,378 | $287,138,657 | $66,852,631 | 29.7 | 23.3 | 74.8 | 123.2 |
| All other sources | $24,834,260 | $8,356,304 | $15,134,741 | $5,864,951 | 33.6 | 38.8 | 64.1 | 42.5 |
| Total expenses, including salaries and wages | $426,568,307 | $125,027,197 | $234,577,277 | $56,342,064 | 29.3 | 24.0 | 81.8 | 121.9 |
| Total number of persons employed | 105,541 | 25,590 | 79,335 | 17,160 | 24.2 | 21.6 | 33.0 | 49.1 |
| Prime movers: | | | | | | | | |
| Number | 13,795 | 2,694 | 11,902 | 2,094 | 19.5 | 17.6 | 15.9 | 28.7 |
| Horsepower | 12,936,755 | 5,867,447 | 7,530,044 | 3,176,974 | 45.4 | 42.2 | 71.8 | 84.7 |
| Steam engines— | | | | | | | | |
| Number | 5,788 | 323 | 6,813 | 327 | 5.6 | 4.8 | −15.0 | −1.2 |
| Horsepower | 1,701,677 | 196,996 | 1,895,382 | 204,673 | 11.6 | 10.8 | −10.2 | −3.8 |
| Steam turbines— | | | | | | | | |
| Number | 1,699 | 331 | 1,034 | 190 | 19.5 | 18.4 | 64.3 | 74.2 |
| Horsepower | 6,747,399 | 1,567,207 | 3,054,396 | 680,069 | 23.2 | 22.3 | 120.9 | 130.4 |
| Water wheels and turbines— | | | | | | | | |
| Number | 3,374 | 1,995 | 2,939 | 1,558 | 59.1 | 53.0 | 14.8 | 28.0 |
| Horsepower | 4,277,273 | 4,092,882 | 2,469,231 | 2,286,546 | 95.7 | 92.6 | 73.2 | 79.0 |
| Internal-combustion engines— | | | | | | | | |
| Number | 2,934 | 45 | 1,116 | 19 | 1.5 | 1.7 | 162.9 | 136.8 |
| Horsepower | 210,406 | 10,362 | 111,035 | 5,686 | 4.9 | 5.1 | 89.5 | 82.2 |
| Dynamos: | | | | | | | | |
| Number | 13,428 | 2,427 | 12,610 | 1,932 | 18.1 | 15.3 | 6.5 | 25.6 |
| Kilowatt capacity | 8,994,407 | 3,954,294 | 5,165,439 | 1,979,397 | 44.0 | 38.3 | 74.1 | 99.8 |
| Number of kilowatt hours generated | 25,438,303,272 | 13,924,464,619 | 11,569,109,885 | 5,845,504,850 | 54.7 | 50.5 | 119.9 | 138.2 |
| Stationary motors served: | | | | | | | | |
| Number | 555,924 | 145,032 | 435,473 | 73,045 | 26.1 | 16.9 | 27.6 | 96.9 |
| Horsepower | 9,216,330 | 3,360,371 | 4,130,619 | 1,283,769 | 36.5 | 31.1 | 123.1 | 161.8 |
| Number of customers | 7,178,703 | 1,686,284 | 3,837,518 | [2] | 23.5 | [2] | 87.1 | [2] |

[1] A minus sign (−) denotes decrease.

[2] Figures not available.

It is interesting to find that the actual increase in number of hydroelectric plants since 1912 has been only 34, or 15.1 per cent, while the number of all stations has increased 25.3 per cent. In every other important respect, however, the rate of increase has been much more rapid for the water-power plants. The value of plant and equipment increased 51.3 per cent as opposed to an increase of only 40.7 per cent for all stations, until at present nearly half the total investment in central stations, 45.6 per cent, is found in the 259 hydroelectric plants. The rate of increase in other items appears fully to have warranted this more rapid growth in investment. For instance, the horsepower of prime movers increased 84.7 per cent and the total dynamo capacity 99.8 per cent, while the corresponding growth for all stations was only 71.8 per cent and 74.1 per cent, respectively. Further, the income from the sale of current has increased 123.2 per cent, from $66,852,631 in 1912 to $149,224,378 in 1917, an absolute percentage gain of 48.4 per cent over the rate of increase shown by all stations, which was 74.8 per cent. The increase in expenses was almost equally rapid, 121.9 per cent, though relatively not so great as in the case of central stations in general. At the present time, accordingly, these hydroelectric plants report 29.9 per cent of the total income and 29.3 per cent of the total expenses, while in 1912 these proportions were 24.1 and 24, respectively. The growth in number of kilowatt hours generated, while more rapid for hydroelectric stations (138.2 per cent) than for all stations (119.9 per cent), has not been relatively so great as the increase in income from the sale of current. In other words, it would appear that the rates charged for service may have decreased somewhat more rapidly for all stations than for hydroelectric stations, since the income from electric service for the former increased only 74.8 per cent, while the number of kilowatt hours generated increased 119.9 per cent, an absolute percentage difference of 45.1 per cent as opposed to an absolute percentage difference in the case of hydroelectric plants of only 15 per cent. Both groups apparently have been utilizing a given amount of generating equipment much more effectively than at earlier periods, while the fact that the

dynamo capacity of hydroelectric stations has increased much more rapidly than the horsepower capacity (99.8 as opposed to 84.7 per cent) indicates that in 1912 these stations probably had a good deal of excess water-power development.

**Table 27** — ALL GENERATING STATIONS AND HYDROELECTRIC STATIONS COMPARED: 1917.

| | All generating stations—Number or amount. | Stations reporting water power of 1,000 horsepower and over. | |
|---|---|---|---|
| | | Number or amount. | Per cent of total. |
| Number of plants | 5,124 | 259 | 5.1 |
| Number of separate generating stations | 5,824 | 684 | 11.7 |
| Number of cities, towns, etc., served by generating plants | 11,364 | 2,497 | 22.0 |
| Value of plant and equipment | $2,952,423,577 | $1,396,619,224 | 47.3 |
| Total income | $494,972,405 | $157,580,682 | 31.8 |
| Light, heat, and power, including free service | $471,063,414 | $149,224,378 | 31.8 |
| All other sources | $23,908,991 | $8,356,304 | 35.0 |
| Total expenses, including salaries and wages | $400,445,429 | $125,027,197 | 31.2 |
| Total number of persons employed | 99,666 | 25,590 | 25.7 |
| Total horsepower | 12,875,522 | 5,867,447 | 45.6 |
| Steam engines and steam turbines— | | | |
| Number | 7,300 | 654 | 9.0 |
| Horsepower | 8,391,816 | 1,764,203 | 21.0 |
| Water wheels and turbines— | | | |
| Number | 3,358 | 1,995 | 59.4 |
| Horsepower | 4,274,479 | 4,092,882 | 95.8 |
| Internal-combustion engines— | | | |
| Number | 2,914 | 45 | 1.5 |
| Horsepower | 209,227 | 10,362 | 5.0 |
| Kilowatt capacity of dynamos | 8,943,423 | 3,954,204 | 44.2 |
| Output of stations | 29,807,378,386 | 16,018,906,900 | 53.7 |
| Kilowatt hours generated | 25,438,303,272 | 13,924,464,619 | 54.7 |
| Kilowatt hours purchased | 4,369,075,114 | 2,094,442,371 | 47.9 |
| Kilowatt hours sold | 24,661,331,266 | 13,148,946,560 | 53.3 |
| For light | 4,772,277,255 | 1,120,506,702 | 23.5 |
| For power | 12,622,123,027 | 7,523,445,685 | 59.6 |
| To other companies | 7,266,930,984 | 4,504,994,173 | 62.0 |
| Stationary motors served: | | | |
| Number | 509,778 | 145,032 | 28.5 |
| Horsepower | 8,765,570 | 3,360,371 | 38.3 |
| Number of customers | 6,570,430 | 1,686,284 | 25.7 |

*Comparison of hydroelectric and all generating stations.*—It is perhaps more accurate as well as more satisfactory to compare hydroelectric plants with all stations which generate current instead of with all stations in the United States, since a large percentage purchase their current, and accordingly furnish a poor basis of comparison. In Table 27 some of the more detailed relations are worked out in order to show the relative development of water-power plants. All primary power and dynamo equipment not in use has been eliminated from the figures here given. It is significant to find that, while these stations comprise only 5.1 per cent of the total number of central generating plants, they report 11.7 per cent of the separate generating stations, each hydroelectric plant frequently having several different generating stations which supply current to a central point for distribution. Further, as a result of their transmission of current over long distances they serve 22 per cent of all municipalities supplied by generating stations. They represent almost half the investment in plant and equipment (47.3 per cent), receive nearly one-third of the total income (31.8 per cent), incur about one-third of the total expenses (31.2 per cent), and employ a little more than one-fourth of all employees in generating stations (25.7 per cent). The water horsepower which they report is 95.8 per cent of the total, whereas in 1912 the proportion was 92.6 per cent. The character of business done by these water-power plants is indicated by the fact that while they sell 53.3 per cent of all current sold, their proportion of current sold for lighting is only 23.5 per cent, while the proportion sold for power and to other companies is 59.6 per cent and 62 per cent, respectively. The relative number of customers (25.7 per cent) corresponds closely with the relative amount of current delivered for lighting purposes. That the rates of hydroelectric stations are in general much lower than those charged by other generating stations is shown by the fact that while they sell 53.3 per cent of all current, their income from the sale of current is only 31.8 per cent of the total.

**Table 28** — ALL GENERATING STATIONS AND HYDROELECTRIC STATIONS—AVERAGE PER STATION: 1917.

| | All generating stations. | Stations reporting water power of 1,000 horsepower and over. |
|---|---|---|
| Number of separate generating stations | 1 | 3 |
| Number of cities, towns, etc., served by generating stations | 2 | 10 |
| Value of plant and equipment | $576,195 | $5,392,352 |
| Total income | $96,599 | $608,420 |
| Total expenses, including salaries and wages | $78,151 | $482,730 |
| Total number of persons employed | 19 | 99 |
| Total horsepower | 2,513 | 22,654 |
| Kilowatt capacity of dynamos | 1,745 | 15,267 |
| Output of stations | 5,817,209 | 61,849,062 |
| Kilowatt hours generated | 4,964,540 | 53,762,412 |
| Kilowatt hours purchased | 852,669 | 8,086,650 |
| Kilowatt hours sold | 4,812,906 | 50,768,133 |
| For light | 931,358 | 4,326,281 |
| For power | 2,463,334 | 29,048,053 |
| To other companies | 1,418,214 | 17,393,800 |
| Horsepower of stationary motors served | 1,711 | 12,974 |
| Number of customers | 1,282 | 6,511 |

The data given in Table 28, showing the averages per station, will perhaps make clear the great importance and size of hydroelectric plants. They have 2.6 separate generating stations per establishment as opposed to only 1.1 for all generating stations, and they serve 9.6 municipalities per station, while for all generating stations the average is only 2.2. The average value of plant and equipment, $5,392,352, is more than nine times as great as that of all stations in this group, $576,195. It is apparent, however, that the average income, $608,420, is smaller relative to the investment than is the case in all generating stations, in which the average is $96,599. The greater amount of investment per plant has a close relation to the greater capacity and output of stations, the average number of kilowatt hours generated being nearly eleven times as great as for all generating stations. Finally, the economies which result from the decreased amount of labor needed in connection with water-power generation is evidenced by the fact that, while all generating stations report an average of 19.4 of persons employed, the hydroelectric stations, in spite of their far greater output and capacity, employ but five times as many men, or 98.8 per plant. The average investment per kilowatt capacity of dynamos is found to be $353 for hydroelectric stations as compared with $330 for all generating stations in the United States and $312 for all generating stations other than hydroelectric stations.

HYDROELECTRIC STATIONS REPORTING WATER POWER OF 1,000

**Table 29**

| | DIVISION AND STATE. | Number of plants. | Number of separate stations. | Value of plant and equipment. | INCOME. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Aggregate. | Electric service. | | | | All other income. |
| | | | | | | Total. | Light, heat, and power. | Sale of electric current to other public service corporations. | Estimated value of free service. | |
| 1 | UNITED STATES | 259 | 684 | $1,396,619,224 | $157,580,682 | $149,224,378 | $121,382,108 | $27,653,444 | $188,826 | $8,356,304 |
| | GEOGRAPHIC DIVISIONS: | | | | | | | | | |
| 2 | New England | 49 | 106 | 103,442,805 | 18,073,660 | 17,168,329 | 12,892,489 | 4,245,711 | 30,129 | 905,331 |
| 3 | Middle Atlantic | 42 | 70 | 162,678,818 | 22,499,600 | 20,689,888 | 14,598,605 | 6,073,123 | 18,160 | 1,809,712 |
| 4 | East North Central | 40 | 130 | 206,522,074 | 31,648,445 | 30,913,601 | 26,848,662 | 4,028,979 | 35,960 | 734,844 |
| 5 | West North Central | 26 | 67 | 127,655,106 | 12,062,451 | 11,601,759 | 8,989,681 | 2,611,557 | 521 | 460,692 |
| 6 | South Atlantic | 32 | 57 | 97,490,854 | 9,954,988 | 9,527,395 | 8,012,016 | 1,509,949 | 5,430 | 427,593 |
| 7 | South Central | 10 | 34 | 83,375,366 | 5,168,109 | 5,018,766 | 3,259,988 | 1,758,698 | 80 | 149,343 |
| 8 | Mountain | 25 | 98 | 213,566,487 | 19,176,107 | 16,706,120 | 15,033,031 | 1,604,532 | 68,557 | 2,469,987 |
| 9 | Pacific | 35 | 122 | 401,887,714 | 38,997,322 | 37,598,520 | 31,747,636 | 5,820,895 | 29,989 | 1,398,802 |
| | NEW ENGLAND: | | | | | | | | | |
| 10 | Maine | 11 | 31 | 22,348,527 | 2,240,206 | 2,018,850 | 1,506,722 | 483,616 | 28,512 | 221,356 |
| 11 | New Hampshire | 6 | 12 | 11,587,477 | 1,643,718 | 1,514,030 | 911,620 | 602,410 | ..... | 129,688 |
| 12 | Vermont | 14 | 27 | 11,598,014 | 1,300,585 | 1,260,160 | 1,036,136 | 222,474 | 1,550 | 40,425 |
| 13 | Massachusetts | 10 | 20 | 32,235,878 | 5,740,705 | 5,533,622 | 3,946,517 | 1,587,105 | ..... | 207,083 |
| 14 | Rhode Island and Connecticut | 8 | 16 | 25,672,909 | 7,148,446 | 6,841,607 | 5,491,494 | 1,350,106 | 67 | 306,779 |
| | MIDDLE ATLANTIC: | | | | | | | | | |
| 15 | New York | 32 | 56 | 123,591,874 | 17,916,496 | 16,337,818 | 11,899,550 | 4,423,673 | 14,595 | 1,578,678 |
| 16 | Pennsylvania | 10 | 14 | 39,086,944 | 4,583,104 | 4,352,070 | 2,699,055 | 1,649,450 | 3,565 | 231,034 |
| | EAST NORTH CENTRAL: | | | | | | | | | |
| 17 | Ohio and Indiana | 5 | 11 | 17,072,505 | 2,099,201 | 2,055,314 | 1,587,247 | 464,982 | 3,085 | 43,887 |
| 18 | Illinois | 4 | 28 | 45,774,148 | 7,016,185 | 6,810,032 | 6,156,854 | 626,040 | 27,138 | 206,153 |
| 19 | Michigan | 17 | 59 | 112,281,768 | 19,633,305 | 19,223,484 | 17,306,948 | 1,910,999 | 5,537 | 409,821 |
| 20 | Wisconsin | 14 | 32 | 31,393,593 | 2,899,754 | 2,824,771 | 1,797,613 | 1,026,958 | 200 | 74,983 |
| | WEST NORTH CENTRAL: | | | | | | | | | |
| 21 | Minnesota | 11 | 32 | 45,663,552 | 6,019,024 | 5,901,168 | 5,457,906 | 443,176 | 86 | 117,856 |
| 22 | Iowa and Missouri | 5 | 11 | 51,875,734 | 2,739,556 | 2,601,363 | 873,505 | 1,727,423 | 435 | 138,193 |
| 23 | South Dakota | 3 | 4 | 8,148,755 | 626,595 | 513,430 | 496,721 | 16,709 | ..... | 113,165 |
| 24 | Nebraska | 3 | 8 | 2,553,532 | 225,796 | 217,592 | 163,033 | 54,559 | ..... | 8,204 |
| 25 | Kansas | 4 | 12 | 19,413,533 | 2,451,480 | 2,368,206 | 1,998,516 | 369,690 | ..... | 83,274 |
| | SOUTH ATLANTIC: | | | | | | | | | |
| 26 | Virginia and West Virginia | 9 | 19 | 22,895,884 | 1,586,449 | 1,548,885 | 1,490,771 | 52,804 | 5,250 | 37,564 |
| 27 | North Carolina | 10 | 14 | 30,667,521 | 4,745,294 | 4,612,382 | 3,905,388 | 706,814 | 180 | 132,912 |
| 28 | South Carolina | 8 | 16 | 26,768,794 | 2,255,597 | 2,040,962 | 1,673,971 | 366,991 | ..... | 214,635 |
| 29 | Georgia and Florida | 5 | 8 | 17,158,655 | 1,367,648 | 1,325,166 | 941,886 | 383,280 | ..... | 42,482 |
| | SOUTH CENTRAL: | | | | | | | | | |
| 30 | Tennessee | 5 | 11 | 49,246,609 | 2,717,534 | 2,684,449 | 1,485,236 | 1,199,213 | ..... | 33,085 |
| 31 | Alabama, Arkansas, and Texas | 5 | 23 | 34,128,757 | 2,450,575 | 2,334,317 | 1,774,752 | 550,485 | 80 | 116,258 |
| | MOUNTAIN: | | | | | | | | | |
| 32 | Montana | 5 | 17 | 83,214,313 | 9,016,247 | 7,305,387 | 6,531,841 | 773,546 | ..... | 1,710,860 |
| 33 | Idaho | 6 | 15 | 24,770,195 | 1,691,890 | 1,577,864 | 1,458,094 | 103,470 | 16,300 | 114,026 |
| 34 | Colorado | 5 | 22 | 29,941,692 | 2,357,668 | 2,275,185 | 2,011,795 | 263,140 | 250 | 82,483 |
| 35 | Arizona and Nevada | 4 | 8 | 19,589,203 | 1,122,097 | 1,025,418 | 955,383 | 70,035 | ..... | 96,679 |
| 36 | Utah | 5 | 36 | 56,051,084 | 4,988,205 | 4,522,266 | 4,075,918 | 394,341 | 52,007 | 465,939 |
| | PACIFIC: | | | | | | | | | |
| 37 | Washington | 10 | 23 | 33,505,118 | 3,355,752 | 3,203,114 | 3,163,629 | 121,830 | 7,655 | 62,638 |
| 38 | Oregon | 7 | 12 | 15,333,674 | 1,060,488 | 1,021,446 | 992,299 | 27,197 | 1,950 | 39,042 |
| 39 | California | 18 | 87 | 353,048,922 | 34,581,082 | 33,283,960 | 27,591,708 | 5,671,868 | 20,384 | 1,297,122 |

HORSEPOWER OR MORE, BY GEOGRAPHIC DIVISIONS AND STATES: 1917.

| Total expenses, including salaries and wages. | Total number of persons employed. | PRIMARY POWER. | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Aggregate. | | Steam engines. | | | | | | | | | | |
| | | | | Total. | | 500 horsepower or under. | | Over 500 and under 2,000 horsepower. | | 2,000 and under 5,000 horsepower. | | 5,000 horsepower and over. | | |
| | | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | |
| $125,027,197 | 25,590 | 2,694 | 5,867,447 | 323 | 196,996 | 233 | 57,279 | 71 | 65,512 | 14 | 37,298 | 5 | 36,907 | 1 |
| 14,102,827 | 3,186 | 494 | 559,452 | 44 | 21,774 | 27 | 8,491 | 17 | 13,280 | ..... | ..... | ..... | ..... | 2 |
| 17,513,593 | 3,221 | 419 | 1,043,847 | 54 | 40,708 | 39 | 9,478 | 11 | 9,430 | 2 | 5,000 | 2 | 16,800 | 3 |
| 25,372,385 | 5,837 | 504 | 911,638 | 81 | 45,407 | 53 | 13,880 | 26 | 27,361 | 2 | 4,160 | ..... | ..... | 4 |
| 10,906,843 | 2,208 | 220 | 458,355 | 30 | 12,317 | 36 | 8,187 | 2 | 1,450 | 1 | 2,680 | ..... | ..... | 5 |
| 8,051,035 | 1,372 | 216 | 606,323 | 9 | 5,500 | 5 | 1,250 | 3 | 2,250 | 1 | 2,000 | ..... | ..... | 6 |
| 4,902,960 | 928 | 115 | 318,214 | 35 | 7,960 | 33 | 6,570 | 2 | 1,390 | ..... | ..... | ..... | ..... | 7 |
| 12,526,371 | 2,563 | 287 | 658,829 | 31 | 20,334 | 25 | 5,340 | 6 | 6,951 | 3 | 8,043 | ..... | ..... | 8 |
| 31,651,183 | 6,275 | 349 | 1,280,786 | 27 | 42,996 | 15 | 4,074 | 4 | 8,400 | 5 | 15,415 | 3 | 20,107 | 9 |
| 1,647,106 | 434 | 154 | 81,192 | 13 | 5,800 | 10 | 3,500 | 3 | 2,300 | ..... | ..... | ..... | ..... | 10 |
| 1,048,578 | 267 | 60 | 62,264 | 7 | 4,389 | 3 | 1,189 | 4 | 3,200 | ..... | ..... | ..... | ..... | 11 |
| 995,870 | 253 | 83 | 59,608 | 6 | 2,435 | 5 | 1,685 | 1 | 750 | ..... | ..... | ..... | ..... | 12 |
| 4,493,544 | 928 | 106 | 209,085 | 5 | 2,425 | 3 | 875 | 2 | 1,550 | ..... | ..... | ..... | ..... | 13 |
| 5,017,729 | 1,304 | 91 | 147,303 | 13 | 6,725 | 6 | 1,245 | 7 | 5,480 | ..... | ..... | ..... | ..... | 14 |
| 13,673,205 | 2,416 | 338 | 822,224 | 73 | 35,508 | 29 | 6,278 | 11 | 9,430 | 1 | 3,000 | 2 | 16,800 | 15 |
| 3,840,388 | 805 | 81 | 221,623 | 11 | 5,200 | 10 | 3,200 | ..... | ..... | 1 | 2,000 | ..... | ..... | 16 |
| 1,823,469 | 335 | 98 | 83,671 | 5 | 3,920 | 2 | 520 | 3 | 3,400 | ..... | ..... | ..... | ..... | 17 |
| 5,720,813 | 1,529 | 134 | 169,050 | 34 | 17,090 | 26 | 7,530 | 8 | 9,560 | ..... | ..... | ..... | ..... | 18 |
| 15,460,978 | 3,492 | 235 | 504,719 | 28 | 17,407 | 15 | 3,746 | 11 | 9,561 | 2 | 4,160 | ..... | ..... | 19 |
| 2,367,125 | 481 | 127 | 184,186 | 14 | 6,990 | 10 | 2,090 | 4 | 4,900 | ..... | ..... | ..... | ..... | 20 |
| 5,354,491 | 1,158 | 89 | 149,117 | 18 | 4,467 | 17 | 3,717 | 1 | 750 | ..... | ..... | ..... | ..... | 21 |
| 2,478,676 | 337 | 52 | 179,760 | 12 | 3,100 | 11 | 2,400 | 1 | 700 | ..... | ..... | ..... | ..... | 22 |
| 535,950 | 88 | 13 | 14,500 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 23 |
| 193,405 | 39 | 18 | 9,650 | 4 | 800 | 4 | 800 | ..... | ..... | ..... | ..... | ..... | ..... | 24 |
| 2,344,315 | 586 | 49 | 105,928 | 5 | 3,950 | 4 | 1,270 | ..... | ..... | 1 | 2,680 | ..... | ..... | 25 |
| 1,515,234 | 341 | 54 | 74,540 | 3 | 1,900 | 1 | 400 | 2 | 1,500 | ..... | ..... | ..... | ..... | 26 |
| 2,873,014 | 467 | 49 | 203,700 | 1 | 250 | 1 | 250 | ..... | ..... | ..... | ..... | ..... | ..... | 27 |
| 2,521,252 | 315 | 69 | 239,650 | 2 | 500 | 2 | 500 | ..... | ..... | ..... | ..... | ..... | ..... | 28 |
| 1,141,535 | 249 | 44 | 88,438 | 3 | 2,850 | 1 | 100 | 1 | 750 | 1 | 2,000 | ..... | ..... | 29 |
| 2,522,762 | 355 | 42 | 150,074 | 7 | 1,490 | 7 | 1,490 | ..... | ..... | ..... | ..... | ..... | ..... | 30 |
| 2,380,198 | 573 | 73 | 168,140 | 28 | 6,470 | 26 | 5,080 | 2 | 1,390 | ..... | ..... | ..... | ..... | 31 |
| 4,909,974 | 576 | 72 | 268,157 | 6 | 835 | 6 | 835 | ..... | ..... | ..... | ..... | ..... | ..... | 32 |
| 1,348,880 | 311 | 49 | 49,615 | 1 | 250 | 1 | 250 | ..... | ..... | ..... | ..... | ..... | ..... | 33 |
| 1,820,039 | 426 | 64 | 86,689 | 20 | 7,455 | 10 | 3,855 | 4 | 3,600 | ..... | ..... | ..... | ..... | 34 |
| 793,574 | 197 | 19 | 35,415 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 35 |
| 3,653,904 | 1,053 | 83 | 218,923 | 7 | 11,794 | 2 | 400 | 2 | 3,351 | 3 | 8,043 | ..... | ..... | 36 |
| 2,625,962 | 825 | 45 | 133,249 | 2 | 255 | 2 | 255 | ..... | ..... | ..... | ..... | ..... | ..... | 37 |
| 955,324 | 262 | 42 | 36,181 | 8 | 3,550 | 6 | 1,850 | 2 | 1,700 | ..... | ..... | ..... | ..... | 38 |
| 28,069,897 | 5,188 | 262 | 1,114,356 | 17 | 39,191 | 7 | 1,989 | 2 | 1,700 | 5 | 15,415 | 3 | 20,107 | 39 |

## HYDROELECTRIC STATIONS REPORTING WATER POWER OF 1,000 HORSEPOWER

**Table 29**—Continued.

PRIMARY POWER—continued.

| | DIVISION AND STATE. | Steam turbines. | | | | | | | | | | Internal-combustion engines. | | Water wheels and motors. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total. | | 500 horsepower or under. | | Over 500 and under 2,000 horsepower. | | 2,000 and under 5,000 horsepower. | | 5,000 horsepower and over. | | | | Total. | | 500 horsepower or under. | | Over 500 and under 2,000 horsepower | |
| | | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. |
| 1 | UNITED STATES | 331 | 1,567,207 | 22 | 5,414 | 137 | 144,165 | 70 | 216,393 | 102 | 1,201,235 | 45 | 10,362 | 1,995 | 4,092,582 | 778 | 212,470 | 717 | 716,617 |
| | GEOGRAPHIC DIVISIONS: | | | | | | | | | | | | | | | | | | |
| 2 | New England | 67 | 217,105 | 5 | 238 | 30 | 32,141 | 19 | 59,285 | 13 | 125,442 | 3 | 500 | 380 | 320,072 | 247 | 65,105 | 96 | 84,707 |
| 3 | Middle Atlantic | 43 | 164,888 | 4 | 607 | 18 | 16,339 | 9 | 30,076 | 12 | 117,866 | .... | ..... | 322 | 838,251 | 96 | 26,085 | 114 | 113,706 |
| 4 | East North Central | 80 | 489,155 | .... | ..... | 31 | 31,947 | 16 | 51,448 | 33 | 405,760 | 8 | 1,175 | 425 | 405,899 | 210 | 57,506 | 164 | 150,373 |
| 5 | West North Central | 34 | 140,959 | 2 | 600 | 16 | 15,319 | 6 | 14,720 | 10 | 110,320 | 21 | 5,965 | 126 | 299,114 | 50 | 12,679 | 48 | 48,935 |
| 6 | South Atlantic | 26 | 81,060 | 1 | 500 | 13 | 15,025 | 8 | 20,535 | 4 | 45,000 | .... | ..... | 181 | 519,768 | 54 | 14,610 | 67 | 70,808 |
| 7 | South Central | 13 | 73,620 | 4 | 1,650 | 4 | 4,570 | .... | ..... | 5 | 67,400 | 10 | 1,610 | 57 | 235,024 | 16 | 3,200 | 10 | 11,334 |
| 8 | Mountain | 13 | 40,882 | 2 | 544 | 8 | 8,890 | .... | ..... | 3 | 31,448 | 1 | 25 | 239 | 597,588 | 50 | 13,667 | 122 | 127,571 |
| 9 | Pacific | 55 | 359,537 | 4 | 1,275 | 17 | 19,934 | 12 | 40,329 | 22 | 297,999 | 2 | 1,087 | 205 | 877,100 | 55 | 19,408 | 93 | 103,183 |
| | NEW ENGLAND: | | | | | | | | | | | | | | | | | | |
| 10 | Maine | 5 | 8,000 | .... | ..... | 2 | 2,000 | 3 | 6,000 | .... | ..... | .... | ..... | 136 | 67,392 | 102 | 28,712 | 32 | 20,680 |
| 11 | New Hampshire | 1 | 8,000 | .... | ..... | .... | ..... | .... | ..... | 1 | 8,000 | 2 | 450 | 50 | 49,425 | 31 | 7,475 | 11 | 9,950 |
| 12 | Vermont | 7 | 9,650 | .... | ..... | 6 | 5,650 | 1 | 4,000 | .... | ..... | 1 | 50 | 69 | 47,473 | 41 | 13,184 | 21 | 18,089 |
| 13 | Massachusetts | 22 | 84,490 | .... | ..... | 12 | 13,633 | 7 | 29,215 | 3 | 41,642 | .... | ..... | 79 | 122,170 | 41 | 9,136 | 21 | 17,434 |
| 14 | Rhode Island and Connecticut | 32 | 106,006 | 5 | 238 | 10 | 10,858 | 8 | 20,070 | 9 | 75,800 | .... | ..... | 46 | 33,612 | 32 | 6,658 | 11 | 11,954 |
| | MIDDLE ATLANTIC: | | | | | | | | | | | | | | | | | | |
| 15 | New York | 31 | 106,190 | 3 | 107 | 16 | 14,973 | 6 | 19,410 | 6 | 71,700 | .... | ..... | 204 | 680,526 | 85 | 22,020 | 75 | 77,440 |
| 16 | Pennsylvania | 12 | 58,698 | 1 | 500 | 2 | 1,366 | 3 | 10,666 | 6 | 46,166 | .... | ..... | 58 | 157,725 | 11 | 3,459 | 39 | 36,266 |
| | EAST NORTH CENTRAL: | | | | | | | | | | | | | | | | | | |
| 17 | Ohio and Indiana | 9 | 42,400 | .... | ..... | 3 | 3,850 | 3 | 12,680 | 3 | 25,870 | 1 | 350 | 83 | 37,001 | 71 | 22,351 | 12 | 14,650 |
| 18 | Illinois | 22 | 93,950 | .... | ..... | 8 | 7,532 | 7 | 19,080 | 7 | 67,332 | .... | ..... | 78 | 58,020 | 69 | 17,320 | 2 | 1,500 |
| 19 | Michigan | 35 | 307,502 | .... | ..... | 11 | 9,762 | 6 | 19,682 | 18 | 278,058 | .... | ..... | 172 | 179,810 | 33 | 10,597 | 114 | 82,413 |
| 20 | Wisconsin | 14 | 45,303 | .... | ..... | 9 | 10,803 | .... | ..... | 5 | 34,500 | 7 | 825 | 92 | 131,068 | 37 | 7,238 | 36 | 51,810 |
| | WEST NORTH CENTRAL: | | | | | | | | | | | | | | | | | | |
| 21 | Minnesota | 12 | 48,810 | .... | ..... | 7 | 7,460 | 2 | 5,360 | 3 | 36,000 | 8 | 1,055 | 51 | 94,785 | 13 | 3,750 | 34 | 35,535 |
| 22 | Iowa and Missouri | .... | ..... | .... | ..... | .... | ..... | .... | ..... | .... | ..... | .... | ..... | 39 | 176,660 | 15 | 2,500 | 2 | 1,700 |
| 23 | South Dakota | 4 | 7,750 | .... | ..... | 1 | 1,070 | 3 | 6,680 | .... | ..... | .... | ..... | 9 | 6,750 | 2 | 600 | 7 | 6,150 |
| 24 | Nebraska | 3 | 3,000 | .... | ..... | 3 | 3,000 | .... | ..... | .... | ..... | 3 | 150 | 8 | 5,100 | 5 | 1,100 | 3 | 4,000 |
| 25 | Kansas | 15 | 81,399 | 2 | 600 | 5 | 3,799 | 1 | 2,080 | 7 | 74,320 | 10 | 4,760 | 19 | 15,819 | 15 | 4,669 | 2 | 1,550 |
| | SOUTH ATLANTIC: | | | | | | | | | | | | | | | | | | |
| 26 | Virginia and West Virginia | 13 | 21,550 | .... | ..... | 9 | 11,025 | 4 | 10,525 | .... | ..... | .... | ..... | 38 | 51,090 | 12 | 3,090 | 19 | 15,600 |
| 27 | North Carolina | 5 | 40,000 | .... | ..... | 1 | 1,000 | 1 | 4,000 | 3 | 35,000 | .... | ..... | 43 | 103,450 | 23 | 6,700 | 6 | 6,100 |
| 28 | South Carolina | 3 | 11,500 | 1 | 500 | 1 | 1,000 | .... | ..... | 1 | 10,000 | .... | ..... | 64 | 227,650 | 8 | 2,320 | 28 | 34,930 |
| 29 | Georgia and Florida | 5 | 8,010 | .... | ..... | 2 | 2,000 | 3 | 6,010 | .... | ..... | .... | ..... | 36 | 77,578 | 11 | 2,500 | 14 | 20,178 |
| | SOUTH CENTRAL: | | | | | | | | | | | | | | | | | | |
| 30 | Tennessee | 4 | 19,150 | .... | ..... | 2 | 1,750 | .... | ..... | 2 | 17,400 | .... | ..... | 31 | 129,434 | 5 | 1,400 | 4 | 6,534 |
| 31 | Alabama, Arkansas, and Texas | 9 | 54,470 | 4 | 1,650 | 2 | 2,820 | .... | ..... | 3 | 50,000 | 10 | 1,610 | 26 | 105,590 | 11 | 1,890 | 6 | 4,800 |
| | MOUNTAIN: | | | | | | | | | | | | | | | | | | |
| 32 | Montana | 2 | 1,250 | 1 | 500 | 1 | 750 | .... | ..... | .... | ..... | 1 | 25 | 63 | 266,047 | 4 | 1,207 | 27 | 29,440 |
| 33 | Idaho | .... | ..... | .... | ..... | .... | ..... | .... | ..... | .... | ..... | .... | ..... | 48 | 49,395 | 14 | 2,000 | 31 | 29,195 |
| 34 | Colorado | 8 | 8,184 | 1 | 44 | 7 | 8,140 | .... | ..... | .... | ..... | .... | ..... | 30 | 71,050 | 12 | 4,900 | 17 | 14,150 |
| 35 | Arizona and Nevada | 1 | 10,000 | .... | ..... | .... | ..... | .... | ..... | 1 | 10,000 | .... | ..... | 18 | 25,415 | 4 | 140 | 8 | 7,875 |
| 36 | Utah | 2 | 21,448 | .... | ..... | .... | ..... | .... | ..... | 2 | 21,448 | .... | ..... | 74 | 185,681 | 16 | 5,420 | 39 | 46,911 |
| | PACIFIC: | | | | | | | | | | | | | | | | | | |
| 37 | Washington | 6 | 20,666 | .... | ..... | 4 | 4,999 | 1 | 2,667 | 1 | 13,000 | .... | ..... | 37 | 109,328 | 9 | 2,728 | 13 | 14,800 |
| 38 | Oregon | .... | ..... | .... | ..... | .... | ..... | .... | ..... | .... | ..... | .... | ..... | 34 | 32,631 | 12 | 4,711 | 21 | 20,920 |
| 39 | California | 49 | 338,871 | 4 | 1,275 | 13 | 14,935 | 11 | 37,662 | 21 | 284,999 | 2 | 1,087 | 194 | 735,207 | 34 | 12,029 | 62 | 67,403 |

OR MORE, BY GEOGRAPHIC DIVISIONS AND STATES: 1917—Continued.

| PRIMARY POWER—continued. Water wheels and motors—Continued. 2,000 and under 5,000 horsepower. Number. | 2,000 and under 5,000 horsepower. Horsepower. | 5,000 horsepower and over. Number. | 5,000 horsepower and over. Horsepower. | DYNAMOS. Number. | DYNAMOS. Kilowatts. | OUTPUT OF STATIONS (KILOWATT HOURS). Generated during year. | OUTPUT OF STATIONS (KILOWATT HOURS). Purchased during year. | KILOWATT HOURS SOLD. Total. | KILOWATT HOURS SOLD. Light. | KILOWATT HOURS SOLD. Power. | KILOWATT HOURS SOLD. Other public service corporations. | STATIONARY MOTORS SERVED. Number. | STATIONARY MOTORS SERVED. Horsepower. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 232 | 745,662 | 208 | 2,418,133 | 2,427 | 3,954,294 | 13,924,464,619 | 2,094,442,371 | 13,148,946,560 | 1,120,506,702 | 7,523,445,685 | 4,504,994,173 | 145,032 | 3,360,371 | 1 |
| 25 | 80,200 | 12 | 90,000 | 412 | 389,594 | 924,499,033 | 290,607,255 | 1,036,562,682 | 102,918,624 | 451,063,437 | 482,580,621 | 28,772 | 255,412 | 2 |
| 38 | 121,760 | 74 | 576,700 | 396 | 658,224 | 3,031,473,392 | 572,767,330 | 3,284,881,664 | 95,570,914 | 2,030,318,413 | 1,158,992,337 | 21,538 | 267,579 | 3 |
| 41 | 134,920 | 10 | 63,100 | 479 | 671,046 | 2,206,581,721 | 55,909,119 | 1,704,499,578 | 279,325,245 | 880,088,367 | 545,085,966 | 41,608 | 483,201 | 4 |
| 9 | 32,000 | 19 | 205,500 | 214 | 313,605 | 1,056,906,025 | 145,184,289 | 1,039,149,033 | 112,501,930 | 432,002,603 | 494,644,440 | 15,703 | 286,797 | 5 |
| 21 | 70,450 | 39 | 357,900 | 201 | 388,567 | 1,082,172,773 | 140,952,613 | 1,057,316,757 | 34,274,306 | 823,585,525 | 199,456,926 | 5,677 | 138,419 | 6 |
| 10 | 32,900 | 21 | 187,500 | 113 | 229,318 | 827,436,151 | 325,765,066 | 728,426,471 | 28,422,900 | 213,113,231 | 486,890,340 | 1,846 | 24,773 | 7 |
| 30 | 101,150 | 37 | 355,200 | 275 | 429,672 | 1,861,057,154 | 234,330,816 | 1,786,187,445 | 87,043,367 | 1,342,657,225 | 356,486,853 | 10,234 | 505,865 | 8 |
| 58 | 172,282 | 56 | 582,233 | 337 | 874,268 | 2,934,338,370 | 328,925,883 | 2,511,922,930 | 380,449,416 | 1,350,016,824 | 780,856,690 | 19,654 | 1,398,325 | 9 |
| ..... | ..... | 2 | 12,000 | 99 | 53,227 | 158,649,180 | 25,009,494 | 159,882,109 | 15,270,840 | 91,031,489 | 53,579,780 | 2,807 | 47,737 | 10 |
| 8 | 32,000 | ..... | ..... | 55 | 42,510 | 125,556,049 | 1,299,805 | 114,447,105 | 8,827,071 | 17,083,448 | 88,536,586 | 2,287 | 28,909 | 11 |
| 7 | 15,600 | ..... | ..... | 81 | 42,596 | 55,474,173 | 17,672,069 | 60,303,557 | 5,908,503 | 32,611,451 | 21,783,603 | 2,351 | 30,844 | 12 |
| 10 | 32,600 | 7 | 63,000 | 107 | 145,011 | 322,477,119 | 152,727,263 | 406,913,508 | 26,969,705 | 183,916,371 | 196,027,372 | 6,327 | 45,810 | 13 |
| ..... | ..... | 3 | 15,000 | 70 | 106,250 | 262,342,512 | 93,808,624 | 295,016,403 | 45,942,445 | 126,420,678 | 122,653,280 | 15,000 | 102,112 | 14 |
| 38 | 121,760 | 66 | 458,700 | 312 | 504,234 | 2,278,006,625 | 571,294,980 | 2,639,865,852 | 82,969,964 | 1,800,806,721 | 756,089,167 | 17,229 | 205,800 | 15 |
| ..... | ..... | 8 | 118,000 | 84 | 153,990 | 753,466,767 | 1,472,350 | 645,015,812 | 12,600,950 | 229,511,692 | 402,903,170 | 4,309 | 61,779 | 16 |
| ..... | ..... | ..... | ..... | 25 | 58,212 | 125,049,931 | 5,241,230 | 105,305,738 | 12,329,780 | 54,655,705 | 38,320,253 | 3,015 | 37,034 | 17 |
| ..... | ..... | 7 | 39,200 | 89 | 120,060 | 370,578,036 | 17,746,084 | 315,675,750 | 90,340,807 | 137,034,313 | 88,291,630 | 4,100 | 117,091 | 18 |
| 23 | 72,400 | 2 | 14,400 | 250 | 376,159 | 1,389,882,664 | 30,057,101 | 986,235,839 | 158,424,066 | 608,191,899 | 219,619,874 | 31,156 | 299,681 | 19 |
| 18 | 62,520 | 1 | 9,500 | 115 | 116,615 | 321,071,090 | 2,864,704 | 297,282,251 | 18,221,592 | 80,206,450 | 198,854,209 | 3,337 | 29,395 | 20 |
| ..... | ..... | 4 | 55,500 | 85 | 98,066 | 370,537,183 | 122,601,178 | 412,560,335 | 89,339,036 | 239,489,712 | 83,731,587 | 12,410 | 205,459 | 21 |
| 7 | 22,400 | 15 | 150,000 | 48 | 123,744 | 515,860,279 | 9,594,716 | 481,446,930 | 3,131,415 | 102,952,936 | 375,362,579 | 685 | 5,854 | 22 |
| ..... | ..... | ..... | ..... | 20 | 10,110 | 15,257,373 | 1,406,100 | 13,222,882 | 3,816,677 | 7,660,721 | 1,745,484 | 1,093 | 10,576 | 23 |
| ..... | ..... | ..... | ..... | 17 | 6,600 | 8,294,595 | ..... | 5,790,838 | 2,069,443 | 1,525,668 | 2,195,727 | 281 | 2,874 | 24 |
| 2 | 9,600 | ..... | ..... | 44 | 75,085 | 146,956,595 | 11,582,295 | 126,128,048 | 14,145,369 | 80,373,626 | 31,609,063 | 1,234 | 62,034 | 25 |
| 3 | 12,000 | 4 | 20,400 | 50 | 55,047 | 99,885,872 | 19,606,268 | 92,747,783 | 17,385,947 | 63,065,953 | 7,295,883 | 900 | 19,846 | 26 |
| 5 | 18,550 | 9 | 132,100 | 42 | 133,570 | 351,104,733 | 29,874,487 | 339,961,757 | 11,344,415 | 240,116,921 | 88,500,421 | 1,787 | 33,735 | 27 |
| 9 | 26,000 | 19 | 164,400 | 67 | 143,345 | 469,500,209 | 90,910,158 | 480,052,861 | 3,772,168 | 416,395,193 | 59,885,500 | 796 | 23,072 | 28 |
| 4 | 13,900 | 7 | 41,000 | 42 | 56,605 | 161,681,959 | 561,700 | 144,554,356 | 1,771,776 | 99,007,458 | 43,775,122 | 2,194 | 61,766 | 29 |
| 6 | 24,000 | 16 | 97,500 | 40 | 109,650 | 509,689,622 | 315,625,896 | 449,090,373 | 10,184,620 | 51,359,403 | 387,546,350 | 985 | 13,644 | 30 |
| 4 | 8,900 | 5 | 90,000 | 73 | 119,668 | 317,746,529 | 10,139,170 | 279,336,098 | 18,238,280 | 161,753,828 | 99,343,990 | 861 | 11,129 | 31 |
| 12 | 43,400 | 20 | 192,000 | 76 | 174,375 | 956,567,722 | 229,752,289 | 1,045,888,978 | 26,692,877 | 789,055,294 | 230,140,807 | 6,761 | 301,987 | 32 |
| ..... | ..... | 3 | 18,200 | 39 | 32,365 | 140,138,594 | 3,787,637 | 103,277,015 | 13,974,299 | 78,807,107 | 10,495,609 | 211 | 5,895 | 33 |
| 2 | 8,000 | 5 | 44,000 | 62 | 55,965 | 198,791,316 | 666,639 | 168,829,757 | 11,686,079 | 97,106,440 | 60,037,238 | 2,088 | 55,917 | 34 |
| 6 | 17,400 | ..... | ..... | 15 | 24,975 | 90,630,562 | ..... | 77,755,693 | 4,489,107 | 63,261,384 | 10,005,199 | 868 | 19,896 | 35 |
| 10 | 32,350 | 9 | 101,000 | 33 | 141,992 | 474,928,960 | 124,251 | 390,436,005 | 30,201,005 | 314,427,000 | 45,808,000 | 306 | 122,170 | 36 |
| 6 | 20,500 | 9 | 71,300 | 50 | 86,340 | 229,761,893 | 1,130,756 | 182,549,823 | 50,936,217 | 115,778,448 | 15,835,161 | 4,626 | 57,225 | 37 |
| ..... | ..... | 1 | 7,000 | 41 | 27,160 | 57,854,107 | 4,999,494 | 40,389,403 | 9,601,867 | 28,836,295 | 1,951,241 | 1,966 | 19,847 | 38 |
| 52 | 151,782 | 46 | 503,933 | 246 | 760,768 | 2,646,722,370 | 322,795,933 | 2,238,983,701 | 319,911,332 | 1,206,002,981 | 763,070,288 | 13,952 | 1,321,253 | 39 |

In order to make possible a further study of hydroelectric development in the United States, Table 29 has been prepared to show, by geographic divisions and states, the conditions which are found in large water-power stations. To avoid disclosing the conditions of individual plants, it has been necessary in several instances to group two or more states together. There are, also, 10 states and the District of Columbia which report no water-power plant having primary water-power equipment of 1,000 horsepower or over.

*Geographic distribution.*—From Table 29 it appears that these hydroelectric stations are most numerous (130) in the East North Central division, followed by the Pacific division (122) and the New England division (106). The largest stations, however, are to be found in the Pacific division and Middle Atlantic division. Among the different states, California leads with 87 stations, while Michigan and New York are next, reporting 59 and 56 stations, respectively. No other states approach these. In primary horsepower the Pacific (1,280,786), Middle Atlantic (1,043,847), and East North Central (941,636) divisions easily rank highest. The same divisions also report the highest dynamo capacity, though the order of the last two is reversed. Evidently the Middle Atlantic division has a good deal of excess water horsepower developed, which will later call for an additional amount of generating equipment. It is further surprising to find that the Middle Atlantic division, which stands third in generating capacity, reports the highest amount of current generated, 3,031,473,392 kilowatt hours, as contrasted with 2,934,338,370 in the Pacific division and 2,206,581,721 in the East North Central. This is due to the better load factor and diversity factor which can be secured in the highly developed industrial centers. As might be expected, the hydroelectric plants of California report more horsepower in the aggregate (1,114,356) than do those of any other state. New York ranks second (822,224), followed by Michigan (504,719). In dynamo capacity and number of kilowatt hours generated these states also lead by a wide margin.

The Pacific division reports an investment in hydroelectric stations of $401,887,714, an amount which is almost double that reported by the nearest rivals, the Mountain ($213,566,487) and the East North Central ($206,522,074). The Pacific division again leads in the income from sale of current ($37,598,520), while the Mountain division, which is second in investment, ranks only fifth in income from electric current sold ($16,706,120). California, New York, Michigan, and Montana, which report the highest investment, also report the highest income from electric service. The average income per kilowatt hour sold in the Middle Atlantic division, about 6.3 mills, is lower than in any other division. This is followed by the South Central, with an average rate of nearly 7 mills. Among the several states, South Carolina shows the lowest average rate for all current sold, 4.3 mills. New York reports about 6.2 mills, and Pennsylvania and Montana about 7 mills. The average rate in California, where current must be transmitted over long distances, is about 1.5 cents. It must, however, be remembered that the nature of the service rendered, together with the local conditions, determines what is a reasonable rate for electric service, and no account of these differences can be shown in the general statistics for the industry.

# CHAPTER IV.—PRIMARY POWER EQUIPMENT.

*Central electric stations and electric railways.*—As in 1912, the census of 1917 called for a return of the different types of primary power machines used by central electric stations, together with their number and horsepower capacity. Similar data were collected for central electric stations and for electric railways. As indicated in Chapter II (p. 21), there are numerous isolated plants producing electric current in addition to those public utilities covered by this census, but the combined data for electric stations and street railways indicate the nature of all important changes in the industry.

**Table 30** CENTRAL ELECTRIC STATIONS AND ELECTRIC RAILWAYS—NUMBER, TYPE, AND HORSEPOWER OF PRIMARY POWER MACHINES: 1917, 1912, AND 1907.

| | Total. | | Type of prime movers. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total steam. | | Steam engines. | | Steam turbines. | | Internal-combustion engines. | | Water wheels and turbines. | |
| | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. |
| Total: | | | | | | | | | | | | |
| 1917 | 15,905 | 17,136,947 | 9,228 | 11,992,991 | 6,965 | 2,922,900 | 2,263 | 9,070,091 | 2,987 | 238,700 | 3,690 | 4,905,256 |
| 1912 | 14,591 | 11,191,429 | 10,105 | 8,115,666 | 8,609 | 3,598,470 | 1,496 | 4,517,196 | 1,164 | 135,225 | 3,322 | 2,940,538 |
| 1907 | 14,635 | 6,618,011 | 11,422 | 5,104,800 | 10,793 | 3,751,986 | 629 | 1,352,814 | 504 | 72,163 | 2,709 | 1,441,048 |
| Central stations: | | | | | | | | | | | | |
| 1917 | 13,795 | 12,936,755 | 7,487 | 8,449,076 | 5,788 | 1,701,677 | 1,699 | 6,747,399 | 2,934 | 210,406 | 3,374 | 4,277,273 |
| 1912 | 11,902 | 7,530,044 | 7,847 | 4,949,778 | 6,813 | 1,895,382 | 1,034 | 3,054,396 | 1,116 | 111,035 | 2,939 | 2,469,231 |
| 1907 | 10,908 | 4,098,188 | 8,054 | 2,693,273 | 7,677 | 1,875,863 | 377 | 817,410 | 463 | 55,328 | 2,481 | 1,349,087 |
| Electric railways: | | | | | | | | | | | | |
| 1917 | 2,110 | 4,200,192 | 1,741 | 3,543,915 | 1,177 | 1,221,223 | 564 | 2,322,692 | 53 | 28,294 | 316 | 627,983 |
| 1912 | 2,689 | 3,661,385 | 2,258 | 3,165,888 | 1,796 | 1,703,088 | 462 | 1,462,800 | 48 | 24,190 | 383 | 471,307 |
| 1907 | 3,727 | 2,519,823 | 3,368 | 2,411,527 | 3,116 | 1,876,123 | 252 | 535,404 | 41 | 16,335 | 228 | 91,961 |
| | PER CENT OF INCREASE.[1] | | | | | | | | | | | |
| Total: | | | | | | | | | | | | |
| 1907–1917 | 8.7 | 158.9 | −19.2 | 134.9 | −35.5 | −22.1 | 259.8 | 570.5 | 492.6 | 230.8 | 36.2 | 240.4 |
| 1912–1917 | 9.0 | 53.1 | −8.7 | 47.8 | −19.1 | −18.8 | 51.3 | 100.8 | 156.6 | 76.5 | 11.1 | 66.8 |
| 1907–1912 | −0.3 | 69.1 | −11.5 | 59.0 | −20.2 | −4.1 | 137.8 | 233.9 | 131.0 | 87.4 | 22.6 | 104.0 |
| Central stations: | | | | | | | | | | | | |
| 1907–1917 | 25.4 | 215.7 | −7.0 | 213.7 | −24.6 | −9.3 | 350.7 | 725.5 | 533.7 | 276.9 | 36.0 | 217.0 |
| 1912–1917 | 15.9 | 71.8 | −4.6 | 70.7 | −15.0 | −10.2 | 64.3 | 120.9 | 162.9 | 89.5 | 14.8 | 73.2 |
| 1907–1912 | 8.2 | 83.7 | −2.6 | 83.8 | −11.3 | 1.0 | 174.3 | 273.7 | 141.0 | 98.9 | 18.5 | 83.0 |
| Electric railways: | | | | | | | | | | | | |
| 1907–1917 | −42.0 | 66.7 | −48.3 | 47.0 | −62.2 | −34.9 | 123.8 | 333.8 | ..... | 73.2 | 38.6 | 582.9 |
| 1912–1917 | −21.5 | 14.7 | −22.9 | 11.9 | −34.5 | −28.3 | 22.1 | 58.8 | ..... | 17.0 | −17.5 | 33.2 |
| 1907–1912 | −26.1 | 45.3 | −33.0 | 31.3 | −42.4 | −9.2 | 83.3 | 173.2 | ..... | 48.1 | 68.0 | 412.5 |

[1] A minus sign (−) denotes decrease. Percentages are omitted when base is less than 100.

Accordingly, Table 30 shows the actual increase in number and horsepower of all prime movers for both central stations and electric railways, together with the per cent of increase or decrease in the respective items. From this table it appears that the growth in total horsepower of all kinds for the electric railways has been comparatively slow during the last decade (66.7 per cent), but particularly during the period 1912–1917, when the increase was only 14.7 per cent. However, the rapid decrease in the number of different units, amounting to 42 per cent during the decade, indicates a very marked increase in the size of primary power machines for electric railways. Central stations, on the other hand, not only show some increase in the number of machines, 25.4 per cent during the decade, but also a growth in horsepower more than three times as rapid as that of the street railways (215.7 per cent as opposed to 66.7 per cent). At the present time electric railways have 2,110 prime movers, or 13.3 per cent of the total for electric stations and street railways (15,905), while they report a horsepower of 4,200,192, or 24.5 per cent of the total horsepower (17,136,947).

An examination of the different types of prime movers shows that steam engines have been rapidly displaced by the larger and more efficient steam turbines, which are usually directly connected with an electric generator and occupy far less space than the old reciprocating engines. There has been a rapid decrease both in number and horsepower of steam engines, particularly in the case of the electric railways, where the decrease for the decade has been 62.2 per cent and 34.9 per cent, respectively. The change has been far less marked for central stations. At the present time, however, steam engines furnish 29.1 per cent of the total horsepower reported by street railways, while steam turbines furnish 55.3 per cent. Water wheels and turbines are relatively of much less importance, supplying only 15 per cent of total horsepower, while internal-combustion engines are scarcely used.

DIAGRAM 1.—CENTRAL ELECTRIC STATIONS AND ELECTRIC RAILWAYS—PRIMARY POWER, BY STATES: 1917.

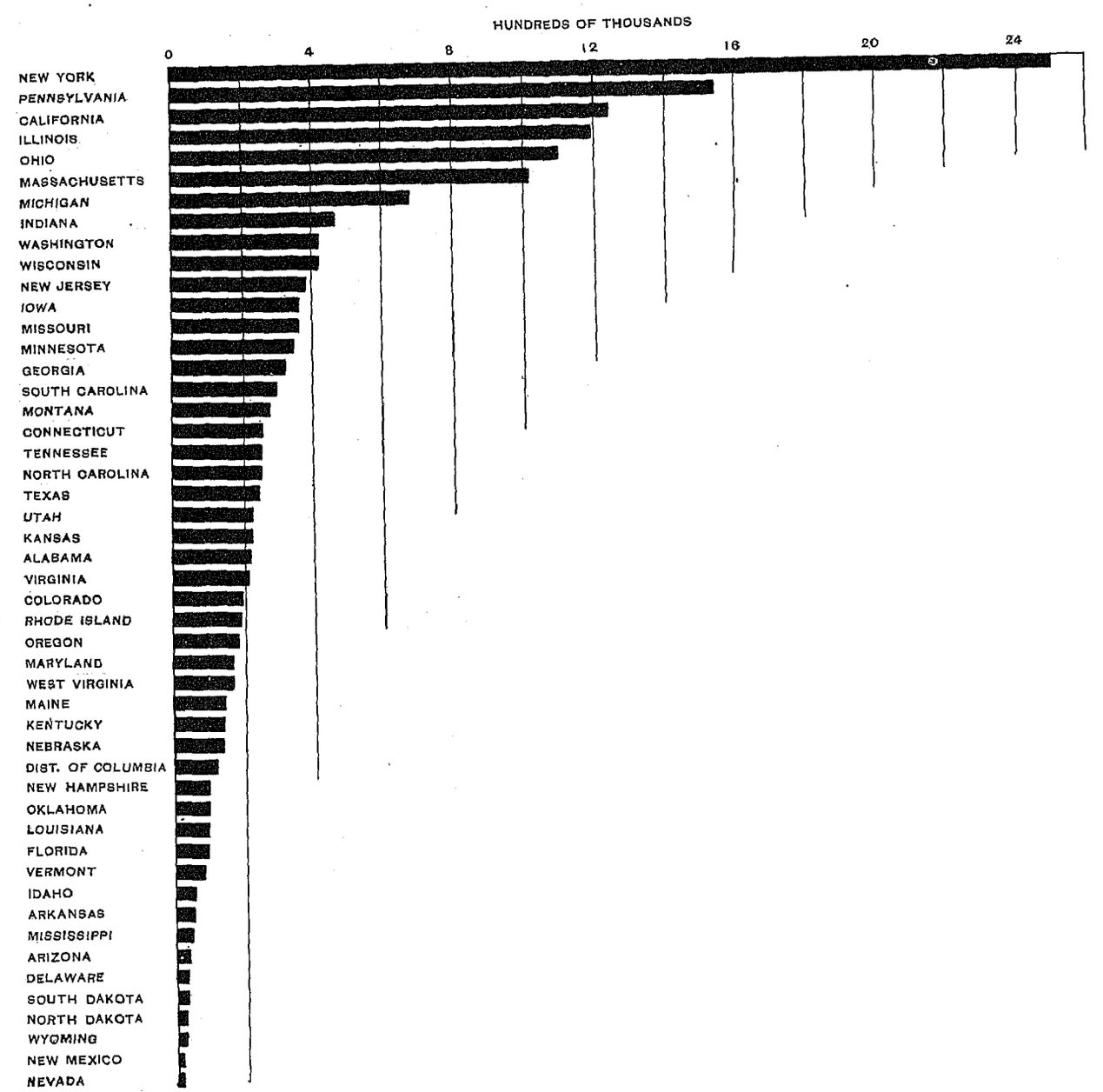


DIAGRAM 2.—PRIMARY POWER, BY CHARACTER OF POWER: 1917.

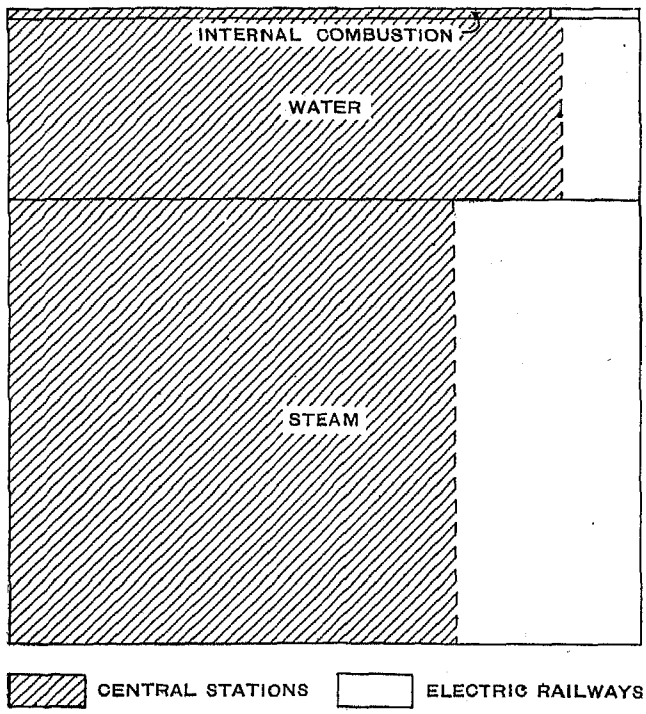
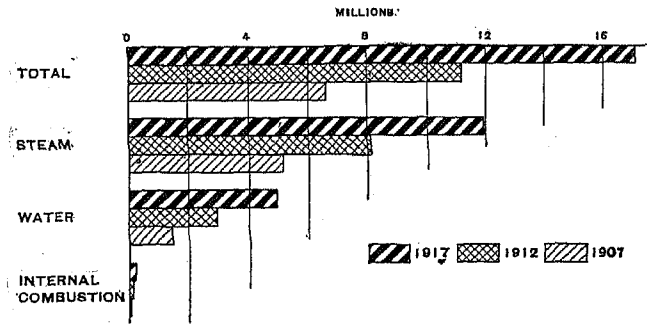



DIAGRAM 3.—PRIMARY HORSEPOWER, BY CHARACTER OF POWER: 1917, 1912, AND 1907.




Central electric stations, on the other hand, report only 13.2 per cent of their horsepower in steam engines, compared with 52.2 per cent in steam turbines, and 33.1 per cent in water wheels. They further return a surprisingly large number of internal-combustion engines, 2,934, which, however, furnish only 1.6 per cent of the horsepower. Finally, it is interesting to find that in every instance the prime movers reported by the street railways are, on the average, much larger than those of electric stations. The former report average horsepower as follows: Steam engines, 1,038; steam turbines, 4,118; water wheels, 1,987; internal-combustion engines, 534. Central stations show an average horsepower of 294 for steam engines, 3,971 for steam turbines, 1,268 for water wheels and turbines, and 72 for internal-combustion engines.

*General comparison of commercial and municipal stations.*—Table 31 shows the relations which exist between the primary power equipment of commercial and municipal central electric stations.

It appears from Table 31 that although municipal stations report 3,408 units, or 24.7 per cent of the total number of prime movers, they have only 859,098 horsepower, or 6.6 per cent of the total. An examination of the per cent of increase shows that, while the municipal plants have reported an increase of 13.2 per cent in the number of steam engines since 1907 and of 29.2 per cent in their horsepower during the same period, commercial plants have experienced a marked decrease of 35.8 per cent in the number of steam engines and of 15.6 per cent in the horsepower of such machines. These figures probably indicate, first, that municipal plants are not generally replacing their old steam engines by steam turbines as are the other group, or, secondly, some may be installing old steam engines instead of steam turbines, in the hope of keeping capital expenditures as low as possible. It does appear, however, that the rate of increase in the number of steam turbines has been much more rapid during the decade for municipal stations than for commercial stations, due to the fact that at the earlier period the former used practically none of this type of prime movers. As will be indicated, however, the relative importance which steam turbines bear to other types of primary power machines is markedly less in the case of municipal plants. The number of internal-combustion engines has been increasing very rapidly for both groups of stations, while the total horsepower has shown by far the greater growth in municipal plants during the past five years—176 per cent as opposed to only 67.6 per cent for the other group of stations. In the matter of water wheels and turbines, municipal plants report a decrease of 1.5 per cent in number during the period from 1912 to 1917, though the decade shows an increase of 73.2 per cent. Commercial plants, on the other hand, have shown a steady growth in number of this type of prime mover during each five-year period. Further, the horsepower capacity of water wheels and turbines in commercial plants has also increased at practically the same rate during the two periods (77.4 and 74.3 per cent, respectively). While for municipal plants there was reported a very small amount of such power in 1907, the growth was very rapid until 1912 (329.2 per cent), and since that year the rate of increase (53.8 per cent) has been relatively slow.

**Table 31** COMMERCIAL AND MUNICIPAL CENTRAL ELECTRIC STATIONS—NUMBER, TYPE, AND HORSEPOWER OF PRIMARY POWER MACHINES: 1917, 1912, AND 1907.

| CLASS OF STATIONS. | Total. | | Type of prime movers. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total steam. | | Steam engines. | | Steam turbines. | | Internal-combustion engines. | | Water wheels and turbines. | |
| | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. |
| Total: | | | | | | | | | | | | |
| 1917 | 13,795 | 12,936,755 | 7,487 | 8,449,076 | 5,788 | 1,701,677 | 1,699 | 6,747,399 | 2,934 | 210,406 | 3,374 | 4,277,273 |
| 1912 | 11,902 | 7,530,044 | 7,847 | 4,949,778 | 6,813 | 1,895,382 | 1,034 | 3,054,396 | 1,116 | 111,035 | 2,939 | 2,469,231 |
| 1907 | 10,998 | 4,098,188 | 8,054 | 2,693,273 | 7,677 | 1,875,863 | 377 | 817,410 | 463 | 55,828 | 2,481 | 1,349,087 |
| Commercial: | | | | | | | | | | | | |
| 1917 | 10,387 | 12,077,657 | 5,287 | 7,852,205 | 3,799 | 1,358,691 | 1,488 | 6,493,514 | 1,991 | 148,574 | 3,109 | 4,076,878 |
| 1912 | 9,326 | 6,970,716 | 5,823 | 4,543,112 | 4,902 | 1,588,889 | 921 | 2,954,223 | 833 | 88,634 | 2,670 | 2,338,970 |
| 1907 | 8,981 | 3,776,837 | 6,268 | 2,408,351 | 5,920 | 1,610,326 | 348 | 798,025 | 385 | 49,746 | 2,328 | 1,318,740 |
| Municipal: | | | | | | | | | | | | |
| 1917 | 3,408 | 859,098 | 2,200 | 596,871 | 1,989 | 342,986 | 211 | 253,885 | 943 | 61,832 | 265 | 200,395 |
| 1912 | 2,576 | 559,328 | 2,024 | 406,666 | 1,911 | 306,493 | 113 | 100,173 | 283 | 22,401 | 269 | 130,261 |
| 1907 | 2,017 | 321,351 | 1,786 | 284,922 | 1,757 | 265,537 | 29 | 19,385 | 78 | 6,082 | 153 | 30,347 |
| | PER CENT OF INCREASE.[1] | | | | | | | | | | | |
| Total: | | | | | | | | | | | | |
| 1907–1917 | 25.4 | 215.7 | −7.0 | 213.7 | −24.6 | −9.3 | 350.7 | 725.5 | 533.7 | 276.9 | 36.0 | 217.0 |
| 1912–1917 | 15.9 | 71.8 | −4.6 | 70.7 | −15.0 | −10.2 | 64.3 | 120.9 | 162.9 | 89.5 | 14.8 | |
| 1907–1912 | 8.2 | 83.7 | −2.6 | 83.8 | −11.3 | 1.0 | 174.3 | 273.7 | 141.0 | 98.9 | 18.5 | 83.0 |
| Commercial: | | | | | | | | | | | | |
| 1907–1917 | 15.6 | 219.8 | −15.7 | 226.0 | −35.8 | −15.6 | 327.6 | 713.7 | 417.1 | 198.7 | 33.5 | 209.1 |
| 1912–1917 | 11.4 | 73.3 | −9.2 | 72.8 | −22.5 | −14.5 | 61.6 | 119.8 | 130.0 | 67.6 | 16.4 | 74.3 |
| 1907–1912 | 3.8 | 84.6 | −7.1 | 88.6 | −17.2 | −1.3 | 164.6 | 270.2 | 116.4 | 78.2 | 14.7 | 77.4 |
| Municipal: | | | | | | | | | | | | |
| 1907–1917 | 69.0 | 167.3 | 23.2 | 109.5 | 13.2 | 29.2 | ..... | 1,209.7 | ..... | 916.6 | 73.2 | 560.3 |
| 1912–1917 | 32.3 | 53.6 | 8.7 | 46.8 | 4.1 | 11.9 | 86.7 | 153.4 | 233.2 | 176.0 | −1.5 | 53.8 |
| 1907–1912 | 27.7 | 74.1 | 13.3 | 42.7 | 8.8 | 15.4 | ..... | 416.8 | ..... | 268.3 | 75.8 | 329.2 |

[1] A minus sign (−) denotes decrease. Percentages are omitted when base is less than 100.

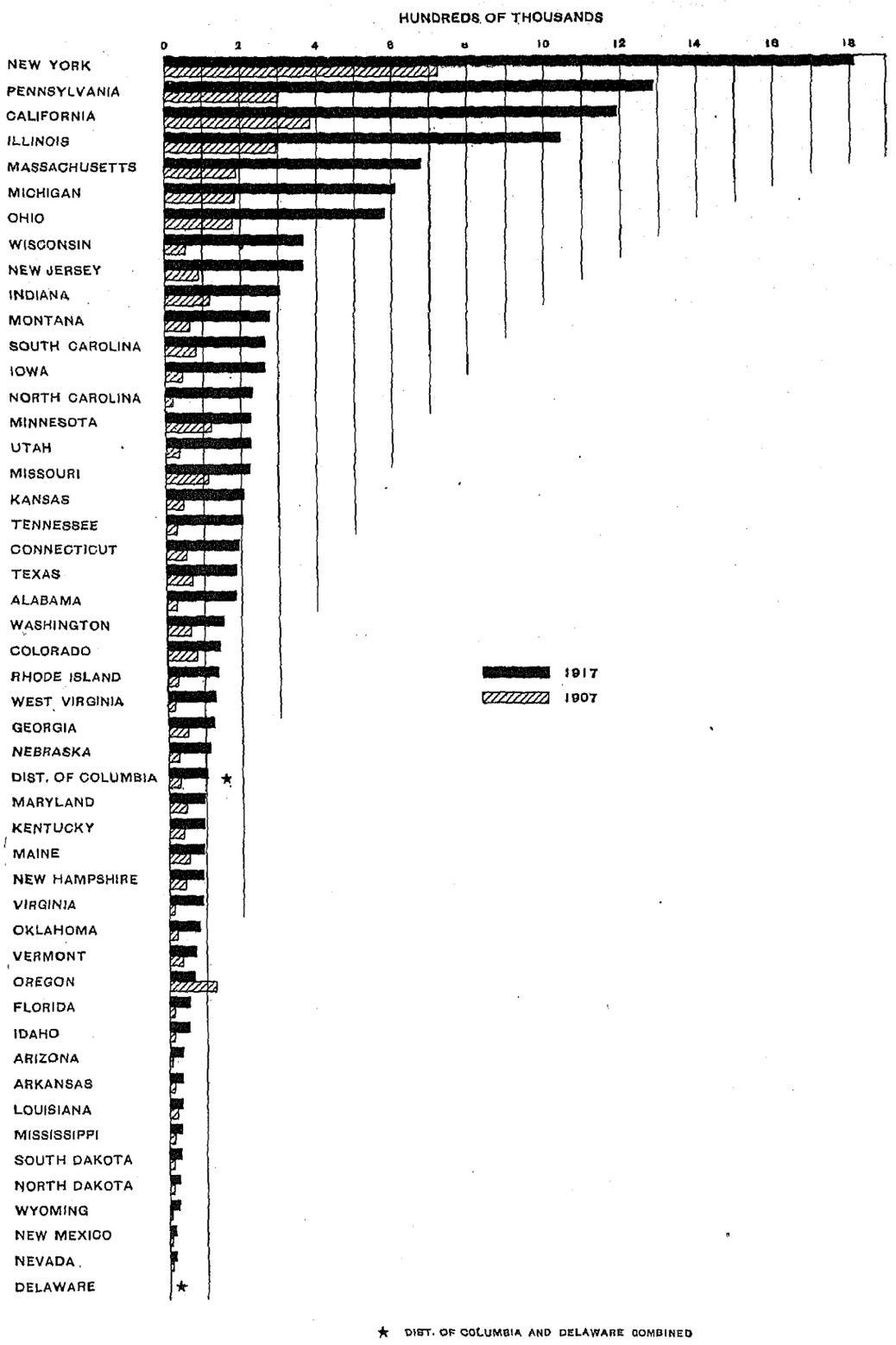
**Table 32** COMMERCIAL AND MUNICIPAL CENTRAL ELECTRIC STATIONS—PER CENT DISTRIBUTION OF DIFFERENT TYPES OF PRIME MOVERS.

| CLASS OF STATIONS. | Census year. | Steam engines. | | Steam turbines. | | Internal-combustion engines. | | Water wheels and turbines. | |
|---|---|---|---|---|---|---|---|---|---|
| | | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. |
| Total | 1917 | 42.0 | 13.2 | 12.3 | 52.2 | 21.3 | 1.6 | 24.5 | 33.1 |
| | 1912 | 57.2 | 25.2 | 8.7 | 40.6 | 9.4 | 1.5 | 24.7 | 32.8 |
| | 1907 | 69.8 | 45.8 | 3.4 | 19.9 | 4.2 | 1.4 | 22.6 | 32.9 |
| Commercial | 1917 | 36.6 | 11.2 | 14.3 | 53.8 | 19.2 | 1.2 | 29.9 | 33.8 |
| | 1912 | 52.6 | 22.8 | 9.9 | 42.4 | 8.9 | 1.3 | 28.6 | 33.6 |
| | 1907 | 65.9 | 42.6 | 3.9 | 21.1 | 4.3 | 1.3 | 25.9 | 34.9 |
| Municipal | 1917 | 58.4 | 39.9 | 6.2 | 29.6 | 27.7 | 7.2 | 7.8 | 23.3 |
| | 1912 | 74.2 | 54.8 | 4.4 | 17.9 | 11.0 | 4.0 | 10.4 | 23.3 |
| | 1907 | 87.1 | 82.6 | 1.4 | 6.0 | 3.9 | 1.9 | 7.6 | 9.4 |

Perhaps a better understanding of the relative importance of the different types of prime movers can be secured from Table 32, which shows the percentage distribution of each type according to number and horsepower of machines. For 1917 steam turbines rank first in importance in the case of commercial stations, comprising 53.8 per cent of the total horsepower, though ranking lowest in number of units. In this group of plants steam engines are still the most numerous (36.6 per cent of the total), though they rank only third in horsepower (11.2 per cent). There has been a complete reversal of the relative importance of these two types of prime movers since 1907. Water wheels and turbines have, throughout the decade, maintained practically the same position, furnishing at the present time 33.8 per cent of the total horsepower of commercial stations and ranking second in the number of separate machines. Internal-combustion engines, while of almost negligible capacity, comprise 19.2 per cent of the total number of prime movers.

Municipal plants furnish some interesting and rather surprising contrasts; for these, steam engines are still far in the lead, both in number and in horsepower. In fact, the per cent of horsepower comprised by these machines is relatively about three and one-half times as great as in the case of the commercial stations, though there has been a constant decrease in comparative importance since 1907. Steam turbines rank second in horsepower (29.6 per cent), but last in number (6.2 per cent); water wheels and turbines have shown no increase in percentage distribution since 1912, and have been subject to a numerical decrease. Finally, internal-combustion engines have shown a marked growth, relatively, both in number and horsepower, due, no doubt, to the fact that such prime movers lend themselves readily and economically to the uses of small stations.

DIAGRAM 4.—CENTRAL ELECTRIC STATIONS—PRIMARY POWER, BY STATES: 1917 AND 1907.



*Extent of use of the different types of prime movers, together with their average size.*—In Table 33 is shown the number of stations which report the different types of prime movers. These figures should be studied in their relation to the number of plants which actually have generating equipment as opposed to the entire number of stations reporting. In 1917 there were 3,417 commercial plants supplied with generating equipment, though only 3,347 of these actually produced current. There were also 1,826 municipal plants in this class, while 1,777 actually generated current. There are, to be sure, a few stations which, while having generating equipment, do not possess primary power machines, as their motive power is purchased from companies which supply mechanical power in the form of water or steam. These, however, are very few in number, and the figures above given can be regarded as practically correct. It is, of course, obvious that many stations report several different types of prime movers.

**Table 33** COMMERCIAL AND MUNICIPAL CENTRAL ELECTRIC STATIONS—DISTRIBUTION BY NUMBER OF STATIONS AND BY TYPES OF PRIME MOVERS: 1917, 1912, AND 1907.

| TYPE OF PRIME MOVERS. | Census year. | Number of stations. | | |
|---|---|---|---|---|
| | | Total. | Commercial. | Municipal. |
| Steam engines | 1917 | 2,920 | 1,745 | 1,175 |
| | 1912 | 3,529 | 2,338 | 1,191 |
| | 1907 | 3,704 | 2,606 | 1,098 |
| Steam turbines | 1917 | 656 | 531 | 125 |
| | 1912 | 454 | 388 | 66 |
| | 1907 | 187 | 170 | 17 |
| Internal-combustion engines | 1917 | 1,802 | 1,222 | 580 |
| | 1912 | 713 | 518 | 195 |
| | 1907 | 294 | 238 | 56 |
| Water wheels and turbines | 1917 | 1,079 | 938 | 141 |
| | 1912 | 1,035 | 915 | 120 |
| | 1907 | 910 | 821 | 89 |

It appears from Table 33 that 1,745 commercial plants, or 51.1 per cent of all having generating equipment, still report the use of steam engines. This is a very high percentage, even though there has been in the last five years a decrease in the number of such stations amounting to 593, or 25.4 per cent. The number of municipal plants reporting steam engines is 1,175, or 64.3 per cent of all stations which have generating equipment, and there has been a decrease of only 1.3 per cent in number since 1912, while there was actually an 8.5 per cent gain between 1907 and 1912, though during the same period there was a decrease of 10.3 per cent in the number of commercial plants so reporting. Steam turbines are returned by 15.5 per cent of commercial plants, as opposed to only 6.8 per cent of municipal plants. Internal-combustion engines are found in 35.8 per cent of the former and 31.8 per cent of the latter. However, 27.5 per cent of the commercial plants have water wheels or turbines, while only 7.7 per cent of municipal plants are supplied with this kind of power.

From Table 34 it can be seen that while there has been a rapid growth since 1912 in the average total horsepower per commercial station, from 1,905 to 2,859, there has been an increase of only 13 during the past five years in the average horsepower per municipal station. These figures, of course, are based on the total number of stations, whether or not they generate current. Were we to consider only those stations which report generating equipment, as suggested above, it would be found that in 1917 the average horsepower per commercial station was 3,535, while the average per municipal station at the same date was 470. The average horsepower per machine for commercial plants has increased during the decade from 421 to 1,163, a gain of 176.2 per cent, as compared with an increase for municipal plants from 159 to 252, or only 58.5 per cent.

**Table 34** COMMERCIAL AND MUNICIPAL CENTRAL ELECTRIC STATIONS—AVERAGE PRIMARY HORSEPOWER PER STATION AND PER MACHINE.

| TYPE OF PRIME MOVERS. | Total. | | | Commercial. | | | Municipal. | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1917 | 1912 | 1907 | 1917 | 1912 | 1907 | 1917 | 1912 | 1907 |
| Total power: | | | | | | | | | |
| Per station | 1,977 | 1,442 | 869 | 2,859 | 1,905 | 1,091 | 371 | 358 | 257 |
| Per machine | 938 | 633 | 373 | 1,163 | 747 | 421 | 252 | 217 | 159 |
| Steam engines and steam turbines: | | | | | | | | | |
| Per machine | 1,128 | 631 | 365 | 1,485 | 780 | 427 | 271 | 201 | 165 |
| Steam engines— | | | | | | | | | |
| Per station | 583 | 537 | 489 | 779 | 680 | 593 | 292 | 257 | 240 |
| Per machine | 204 | 278 | 265 | 358 | 324 | 301 | 172 | 160 | 157 |
| Steam turbines— | | | | | | | | | |
| Per station | 10,286 | 6,728 | 4,371 | 12,229 | 7,614 | 4,694 | 2,031 | 1,518 | 1,140 |
| Per machine | 3,971 | 2,954 | 2,168 | 4,364 | 3,208 | 2,293 | 1,203 | 886 | 668 |
| Internal-combustion engines: | | | | | | | | | |
| Per station | 117 | 156 | 199 | 122 | 171 | 209 | 107 | 115 | 109 |
| Per machine | 72 | 99 | 121 | 75 | 106 | 129 | 66 | 79 | 78 |
| Water wheels and turbines: | | | | | | | | | |
| Per station | 3,964 | 2,386 | 1,483 | 4,346 | 2,556 | 1,606 | 1,421 | 1,086 | 341 |
| Per machine | 1,268 | 840 | 544 | 1,311 | 876 | 566 | 756 | 484 | 198 |

So far as the different types of prime movers are concerned, it is evident that there has been comparatively little increase either in the horsepower per station or per machine for steam engines. Steam turbines, however, have shown a rapid increase in both of these respects, particularly in the case of commercial plants, which in 1912 showed an average per plant reporting such machines of 12,229 horsepower, an absolute gain of 7,535 horsepower over 1907. The average horsepower per machine for this group, also, nearly doubled, from 2,293 in 1907 to 4,364 in 1917. The rate of increase in steam-turbine capacity per station reporting was much less rapid for municipal plants, though the average capacity per machine showed about the same growth. There has been a marked increase, both in the horsepower per station and in the average per machine, for water wheels and turbines, and the proportionate increase has in each instance been more marked for municipal plants. It is, finally, surprising to find that there has been a very noticeable decrease in the average capacity of internal-combustion engines as well as in their horsepower per station. For municipal plants the change has not

been appreciable since 1907, but in the other group there has been a drop from 209 horsepower to 122 horsepower in the station average and from 129 horsepower to 75 horsepower in the average per machine. This decrease in average size of internal-combustion engines is largely occasioned by the fact that there have been so many new and very small commercial plants installed since 1912, particularly in those groups which are not incorporated. For municipal plants, on the other hand, the most rapid rate of increase took place among those small plants which purchase all their current, and, accordingly, the size of the primary power units would be little affected. In this connection it is interesting to observe that the state of New York reports primary power of all kinds far in excess of the capacity returned by any other state, 1,811,066 horsepower, or about 14.2 per cent of the total for the United States. Three other states—Pennsylvania, California, and Illinois—report more than 1,000,000 horsepower. These four states furnish 41.3 per cent of the aggregate for the United States.

*Stations reporting only one type of prime mover.*—In Table 33 the number of stations reporting the different types of prime movers is given. At this point, however, some mention should be made of those stations which report only one type of prime mover, together with the number and horsepower capacity of such machines. Accordingly, in Table 35 are assembled some significant data bearing on this question. It appears, in the first place, that the total number of such stations, 4,144, is equal to 63.3 per cent of all central stations in the United States and 79 per cent of all stations supplied with generating equipment. They also report a total horsepower of 3,661,679, or 28.3 per cent of the United States total. Nearly 38.7 per cent of all generating stations, 2,028, report steam engines only, while 27.1 per cent, or 1,423, are supplied only with internal-combustion engines. That these plants reporting only one type of prime mover are usually the smaller plants is indicated by the fact that, while they return 55.8 per cent of the total number of primary power machines, the total capacity of the same is little more than one-fourth (28.3 per cent) of the total horsepower reported at this census. The averages per station and per machine are less than the corresponding averages for the United States given in Table 34, except in the case of the averages shown for steam turbines in municipal stations and the average per machine for water wheels and turbines in these stations, which are higher.

**Table 35** CENTRAL ELECTRIC STATIONS REPORTING ONLY ONE TYPE OF PRIME MOVER: 1917.

| | Total. | | | Commercial. | | | Municipal. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Number of stations. | Number of machines. | Horsepower. | Number of stations. | Number of machines. | Horsepower. | Number of stations. | Number of machines. | Horsepower. |
| Total | 4,144 | 7,698 | 3,661,679 | 2,519 | 4,911 | 3,095,298 | 1,625 | 2,787 | 566,381 |
| Steam engines only | 2,028 | 3,590 | 626,939 | 1,026 | 1,874 | 345,407 | 1,002 | 1,716 | 281,532 |
| Steam turbines only | 145 | 406 | 1,220,017 | 110 | 326 | 1,105,337 | 35 | 80 | 114,680 |
| Internal-combustion engines only | 1,423 | 2,348 | 133,439 | 925 | 1,515 | 83,030 | 498 | 833 | 50,409 |
| Water wheels or turbines only | 548 | 1,354 | 1,681,284 | 458 | 1,196 | 1,561,524 | 90 | 158 | 119,760 |
| Average per station: | | | | | | | | | |
| Steam engines | | 2 | 309 | | 2 | 337 | | 2 | 281 |
| Steam turbines | | 3 | 8,414 | | 3 | 10,049 | | 2 | 3,277 |
| Internal-combustion engines | | 2 | 94 | | 2 | 90 | | 2 | 101 |
| Water wheels and turbines | | 2 | 3,068 | | 2 | 3,409 | | 2 | 1,331 |
| Average per machine: | | | | | | | | | |
| Steam engines | | | 175 | | | 184 | | | 164 |
| Steam turbines | | | 3,005 | | | 3,391 | | | 1,434 |
| Internal-combustion engines | | | 57 | | | 55 | | | 61 |
| Water wheels and turbines | | | 1,242 | | | 1,306 | | | 758 |
| Per cent of United States totals: | | | | | | | | | |
| Total | 63.3 | 55.8 | 28.3 | 59.6 | 47.3 | 25.6 | 70.1 | 81.8 | 65.9 |
| Steam engines | 31.0 | 62.0 | 36.8 | 24.3 | 49.3 | 25.4 | 43.2 | 86.3 | 82.1 |
| Steam turbines | 2.2 | 23.9 | 18.1 | 2.6 | 21.9 | 17.0 | 1.5 | 37.9 | 45.2 |
| Internal-combustion engines | 21.8 | 80.0 | 63.4 | 21.9 | 76.1 | 55.9 | 21.5 | 88.3 | 81.5 |
| Water wheels and turbines | 8.4 | 40.1 | 39.3 | 10.8 | 38.5 | 38.3 | 3.9 | 59.6 | 59.8 |
| Per cent of stations having generating equipment: | | | | | | | | | |
| Total | 79.0 | | | 73.7 | | | 89.0 | | |
| Steam engines | 38.7 | | | 30.0 | | | 54.9 | | |
| Steam turbines | 2.8 | | | 3.2 | | | 1.9 | | |
| Internal-combustion engines | 27.1 | | | 27.1 | | | 27.3 | | |
| Water wheels and turbines | 10.5 | | | 13.4 | | | 4.9 | | |

The number of commercial establishments which report only one type of machine, 73.7 per cent of those stations having generating equipment, is relatively less important than the corresponding number of municipal plants, which amounts to 89 per cent of this group. In only one instance, however, have these commercial plants reported more than half the primary horsepower of a given kind, 55.9 per cent—that is, in the case of those stations having only internal-combustion engines. The municipal plants in this group, on the other hand, in all instances except one, report by far the greater part of the total municipal horsepower. As is also the case with commercial plants, the lowest relative amount of horsepower is reported by those municipal plants equipped only with steam turbines (45.2 per cent). All of the averages per station and per machine are closer to the United States total averages for the given group in the case of municipal plants.

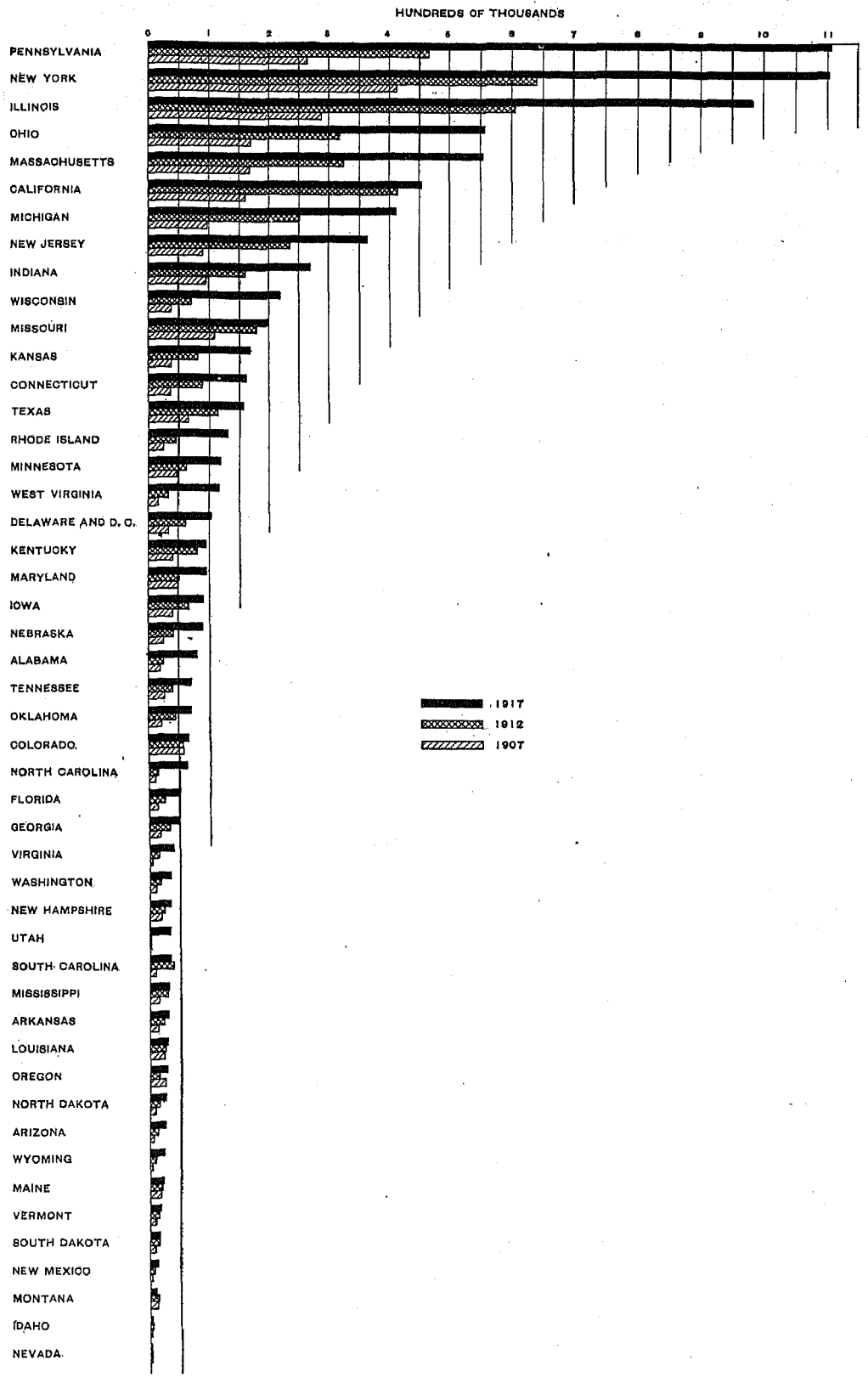
In two instances they are even considerably higher. Steam turbines average 3,277 horsepower per station and 1,434 horsepower per machine, as opposed to United States averages for municipal plants of 2,031 and 1,203, respectively. The average capacity of water wheels and turbines per station is 1,331 horsepower per station and 758 per machine, while the total averages are 1,421 and 756, respectively.

*Steam power.*—It is perhaps worth while to examine somewhat more closely the changes which have been taking place in the different classes of primary power units according to their size. Accordingly, in Table 36 this phase of development has been shown for steam engines and steam turbines since 1907. These machines, of course, secure their motive power, in the main, through the use of coal for fuel under the boilers. The fact, however, must not be overlooked that not all steam is produced in this way. In some sections where oil is abundant and low in price and coal is relatively scarce, the former is actually burned under the boilers in place of other fuel. This frequently happens in Texas, Oklahoma, and parts of California. Gas is also sometimes used. In other sections of the country waste material of different sorts, particularly the refuse from sawmills, is largely or even wholly used in the smaller generating plants in place of coal. These instances are most numerous in some of the Southern states, particularly in Georgia and the Carolinas. More detailed reference to the different kinds of fuel used in steam plants will be made later in the chapter on "Financial statistics."

**Table 36** COMMERCIAL AND MUNICIPAL CENTRAL ELECTRIC STATIONS—STEAM ENGINES AND STEAM TURBINES, BY HORSEPOWER CAPACITY: 1917, 1912, AND 1907.

| CLASS OF STATIONS. | Total. | | Engines grouped according to horsepower. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 500 horsepower or under. | | Over 500 and under 2,000 horsepower. | | 2,000 and under 5,000 horsepower. | | 5,000 horsepower and over. | |
| | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. |
| Total: | | | | | | | | | | |
| 1917 | 7,487 | 8,449,076 | 5,509 | 996,991 | 1,188 | 1,188,319 | 388 | 1,158,816 | 402 | 5,104,950 |
| 1912 | 7,847 | 4,949,778 | 6,320 | 1,092,175 | 1,045 | 980,992 | 294 | 845,381 | 170 | 2,031,230 |
| 1907 | 7,206 | 2,627,450 | 6,248 | 1,035,583 | 747 | 661,746 | 148 | 407,695 | 63 | 522,426 |
| Commercial: | | | | | | | | | | |
| 1917 | 5,287 | 7,852,205 | 3,488 | 661,780 | 1,040 | 1,054,894 | 365 | 1,087,565 | 394 | 5,047,966 |
| 1912 | 5,823 | 4,543,112 | 4,390 | 796,156 | 964 | 906,729 | 281 | 808,997 | 179 | 2,031,230 |
| 1907 | 5,492 | 2,344,032 | 4,584 | 794,205 | 699 | 625,006 | 146 | 402,395 | 63 | 522,426 |
| Municipal: | | | | | | | | | | |
| 1917 | 2,200 | 596,871 | 2,021 | 335,211 | 148 | 133,425 | 23 | 71,251 | 8 | 56,984 |
| 1912 | 2,024 | 406,666 | 1,930 | 295,019 | 81 | 74,263 | 13 | 36,384 | ..... | ..... |
| 1907 | 1,714 | 283,418 | 1,664 | 241,378 | 48 | 36,740 | 2 | 5,300 | ..... | ..... |
| STEAM ENGINES. | | | | | | | | | | |
| Total: | | | | | | | | | | |
| 1917 | 5,788 | 1,701,677 | 5,200 | 906,957 | 484 | 454,039 | 87 | 233,274 | 17 | 107,407 |
| 1912 | 6,813 | 1,895,382 | 6,137 | 1,038,495 | 568 | 510,830 | 92 | 240,794 | 16 | 105,254 |
| 1907 | 6,829 | 1,810,040 | 6,183 | 1,018,566 | 557 | 489,604 | 70 | 186,280 | 19 | 115,590 |
| Commercial: | | | | | | | | | | |
| 1917 | 3,799 | 1,358,691 | 3,253 | 593,538 | 442 | 424,472 | 87 | 233,274 | 17 | 107,407 |
| 1912 | 4,902 | 1,588,889 | 4,253 | 753,542 | 541 | 489,299 | 92 | 240,794 | 16 | 105,254 |
| 1907 | 5,144 | 1,546,007 | 4,535 | 781,673 | 520 | 462,554 | 70 | 186,280 | 19 | 115,590 |
| Municipal: | | | | | | | | | | |
| 1917 | 1,989 | 342,986 | 1,947 | 313,419 | 42 | 29,567 | ..... | ..... | ..... | ..... |
| 1912 | 1,911 | 306,493 | 1,884 | 284,953 | 27 | 21,540 | ..... | ..... | ..... | ..... |
| 1907 | 1,685 | 264,033 | 1,648 | 236,893 | 37 | 27,140 | ..... | ..... | ..... | ..... |
| STEAM TURBINES. | | | | | | | | | | |
| Total: | | | | | | | | | | |
| 1917 | 1,699 | 6,747,399 | 309 | 90,034 | 704 | 734,280 | 301 | 925,542 | 385 | 4,997,543 |
| 1912 | 1,034 | 3,054,396 | 192 | 53,680 | 477 | 470,153 | 202 | 604,587 | 163 | 1,925,976 |
| 1907 | 377 | 817,410 | 65 | 17,017 | 190 | 172,052 | 78 | 221,415 | 44 | 406,926 |
| Commercial: | | | | | | | | | | |
| 1917 | 1,488 | 6,493,514 | 235 | 68,242 | 598 | 630,422 | 278 | 854,291 | 377 | 4,940,559 |
| 1912 | 921 | 2,954,223 | 146 | 42,614 | 423 | 417,430 | 189 | 568,203 | 163 | 1,925,976 |
| 1907 | 348 | 798,025 | 49 | 12,532 | 179 | 162,452 | 76 | 216,115 | 44 | 406,926 |
| Municipal: | | | | | | | | | | |
| 1917 | 211 | 253,885 | 74 | 21,792 | 106 | 103,858 | 23 | 71,251 | 8 | 56,984 |
| 1912 | 113 | 100,173 | 46 | 11,066 | 54 | 52,723 | 13 | 36,384 | ..... | ..... |
| 1907 | 29 | 19,385 | 16 | 4,485 | 11 | 9,600 | 2 | 5,300 | ..... | ..... |
| | PER CENT DISTRIBUTION. | | | | | | | | | |
| STEAM ENGINES. | | | | | | | | | | |
| Total: | | | | | | | | | | |
| 1917 | 100.0 | 100.0 | 89.8 | 53.3 | 8.4 | 26.7 | 1.5 | 13.7 | 0.3 | 6.3 |
| 1912 | 100.0 | 100.0 | 90.1 | 54.8 | 8.3 | 27.0 | 1.4 | 12.7 | 0.2 | 5.6 |
| 1907 | 100.0 | 100.0 | 90.5 | 56.3 | 8.2 | 27.1 | 1.0 | 10.3 | 0.3 | 6.4 |
| Commercial: | | | | | | | | | | |
| 1917 | 100.0 | 100.0 | 85.6 | 43.7 | 11.6 | 31.2 | 2.3 | 17.2 | 0.4 | 7.9 |
| 1912 | 100.0 | 100.0 | 86.8 | 47.4 | 11.0 | 30.8 | 1.9 | 15.2 | 0.3 | 6.6 |
| 1907 | 100.0 | 100.0 | 88.2 | 50.6 | 10.1 | 29.9 | 1.4 | 12.0 | 0.4 | 7.5 |
| Municipal: | | | | | | | | | | |
| 1917 | 100.0 | 100.0 | 97.9 | 91.4 | 2.1 | 8.6 | ..... | ..... | ..... | ..... |
| 1912 | 100.0 | 100.0 | 98.6 | 93.0 | 1.4 | 7.0 | ..... | ..... | ..... | ..... |
| 1907 | 100.0 | 100.0 | 97.8 | 89.7 | 2.2 | 10.3 | ..... | ..... | ..... | ..... |
| STEAM TURBINES. | | | | | | | | | | |
| Total: | | | | | | | | | | |
| 1917 | 100.0 | 100.0 | 18.2 | 1.3 | 41.4 | 10.9 | 17.7 | 13.7 | 22.7 | 74.1 |
| 1912 | 100.0 | 100.0 | 18.6 | 1.8 | 46.1 | 15.4 | 19.5 | 19.8 | 15.8 | 63.1 |
| 1907 | 100.0 | 100.0 | 17.2 | 2.1 | 50.4 | 21.0 | 20.7 | 27.1 | 11.7 | 49.8 |
| Commercial: | | | | | | | | | | |
| 1917 | 100.0 | 100.0 | 15.8 | 1.1 | 40.2 | 9.7 | 18.7 | 13.2 | 25.3 | 76.1 |
| 1912 | 100.0 | 100.0 | 15.9 | 1.4 | 45.9 | 14.1 | 20.5 | 19.3 | 17.7 | 65.2 |
| 1907 | 100.0 | 100.0 | 14.1 | 1.6 | 51.4 | 20.4 | 21.8 | 27.1 | 12.6 | 51.0 |
| Municipal: | | | | | | | | | | |
| 1917 | 100.0 | 100.0 | 35.1 | 8.6 | 50.2 | 40.9 | 10.9 | 28.1 | 3.8 | 22.4 |
| 1912 | 100.0 | 100.0 | 40.7 | 11.0 | 47.8 | 52.6 | 11.5 | 36.3 | ..... | ..... |
| 1907 | 100.0 | 100.0 | 55.2 | 23.1 | 37.9 | 49.5 | 6.9 | 27.3 | ..... | ..... |

DIAGRAM 5.—CENTRAL ELECTRIC STATIONS—STEAM POWER, BY STATES: 1917, 1912, AND 1907.



It is of little significance at present to study the relative importance of steam power as contrasted with the other kinds of primary power without making a separation of the antiquated steam engine from the newer and more efficient steam turbine which has largely taken its place. Some mention has already been made of the general changes in primary power equipment. It should be noted, however, that practically all of the steam engines in both commercial and municipal stations are to be found in the lowest group, "500 horsepower or under," and the average size of these machines is in both cases well under 200 horsepower. It is further significant to find that the decrease in the number of these small machines has been very marked for commercial plants, from 4,535 in 1907 to 3,253 in 1917, accompanied by a no less marked decrease in horsepower capacity, from 781,673 to 593,538. Municipal plants, on the other hand, report an *increase* in number in this small group, from 1,648 in 1907 to 1,947 in 1917, with a corresponding increase in horsepower capacity, from 236,893 to 313,419. In the group between 500 and 2,000 there has been some decrease both in number and horsepower of engines reported by commercial stations. In the next group, while there has been a slight decrease in number of units and their capacity since 1912, there has actually been a considerable increase in both since 1907. The highest group has witnessed very little change and the municipal plants have had at no time any steam engines with a capacity as high as 2,000 horsepower.

The most interesting development in this connection has been the growth in horsepower capacity of steam turbines, though their number is relatively small when compared with the number of steam engines. In both classes of stations these turbines are found to be most numerous in the group between 500 and 2,000 horsepower—598, or 40.2 per cent of the total, for commercial plants, and 106, or 50.2 per cent of the total, for municipal plants. The municipal plants also report the greater part of their steam-turbine capacity, 40.9 per cent of the total, in this group. Commercial stations, on the other hand, have shown a rapid increase in the number and capacity of turbines in the highest grouping, until, in 1917, 76.1 per cent of the total horsepower was furnished by these larger units, which averaged 13,105 horsepower per turbine, as opposed to an average of only 6,318 for steam engines in this group. In the lower groups there is not a wide difference between the average size per unit in commercial and municipal plants. There has been during the last five years a rapid increase in the size of steam turbines directly connected to generators, until at present units of 40,000 to 60,000 horsepower are not uncommon.

**Table 37** STEAM ENGINES AND STEAM TURBINES—PER CENT OF INCREASE [1] (BASED UPON TABLE 36).

| CLASS OF STATIONS. | Total. | | Engines grouped according to horsepower. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 500 horsepower or under. | | Over 500 and under 2,000 horsepower. | | 2,000 and under 5,000 horsepower. | | 5,000 horsepower and over. | |
| | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. |
| Total: | | | | | | | | | | |
| 1907–1917 | 3.9 | 221.6 | −11.8 | −3.7 | 59.0 | 79.6 | 162.2 | 184.2 | ..... | 377.2 |
| 1912–1917 | −4.6 | 70.7 | −13.0 | −8.7 | 13.7 | 21.1 | 32.0 | 37.1 | 124.6 | 151.3 |
| 1907–1912 | 8.9 | 88.4 | 1.3 | 5.5 | 39.9 | 48.2 | 98.6 | 107.4 | ..... | 288.8 |
| Commercial: | | | | | | | | | | |
| 1907–1917 | −3.7 | 235.0 | −23.9 | −16.7 | 48.8 | 68.8 | 150.0 | 170.3 | ..... | 866.2 |
| 1912–1917 | −9.2 | 72.8 | −20.7 | −16.9 | 7.9 | 16.3 | 29.9 | 34.4 | 120.1 | 148.5 |
| 1907–1912 | 6.0 | 93.8 | −4.0 | 0.2 | 37.9 | 45.1 | 92.5 | 101.0 | ..... | 288.8 |
| Municipal: | | | | | | | | | | |
| 1907–1917 | 28.4 | 110.6 | 21.4 | 38.9 | ..... | 263.2 | ..... | 1,244.4 | ..... | ..... |
| 1912–1917 | 8.7 | 46.8 | 4.7 | 13.2 | ..... | 79.7 | ..... | 95.8 | ..... | ..... |
| 1907–1912 | 18.1 | 43.5 | 16.0 | 22.6 | ..... | 102.1 | ..... | 586.5 | ..... | ..... |
| STEAM ENGINES. | | | | | | | | | | |
| Total: | | | | | | | | | | |
| 1907–1917 | −15.2 | −6.0 | −15.9 | −11.0 | −13.1 | −7.3 | ..... | 25.2 | ..... | −7.0 |
| 1912–1917 | −15.0 | −10.2 | −15.3 | −12.7 | −14.8 | −11.1 | ..... | −3.1 | ..... | 2.0 |
| 1907–1912 | −0.2 | 4.7 | −0.8 | 2.0 | 2.0 | 4.3 | ..... | 29.3 | ..... | −8.9 |
| Commercial: | | | | | | | | | | |
| 1907–1917 | −26.2 | −12.1 | −28.3 | −24.1 | −15.0 | −8.2 | ..... | 25.2 | ..... | −7.0 |
| 1912–1917 | −22.5 | −14.5 | −23.5 | −21.2 | −18.3 | −13.2 | ..... | −3.1 | ..... | 2.0 |
| 1907–1912 | −4.7 | 2.8 | −6.2 | −3.6 | 4.0 | 5.8 | ..... | 29.3 | ..... | −8.9 |
| Municipal: | | | | | | | | | | |
| 1907–1917 | 18.0 | 29.9 | 18.1 | 32.3 | ..... | 8.9 | ..... | ..... | ..... | ..... |
| 1912–1917 | 4.1 | 11.0 | 3.3 | 10.0 | ..... | 37.3 | ..... | ..... | ..... | ..... |
| 1907–1912 | 13.4 | 16.1 | 14.3 | 20.3 | ..... | −20.6 | ..... | ..... | ..... | ..... |
| STEAM TURBINES. | | | | | | | | | | |
| Total: | | | | | | | | | | |
| 1907–1917 | 350.7 | 725.5 | ..... | 429.1 | 270.5 | 326.8 | ..... | 318.0 | ..... | 1,128.1 |
| 1912–1917 | 64.3 | 120.9 | 60.9 | 67.7 | 47.6 | 56.2 | 49.0 | 53.1 | 136.2 | 159.5 |
| 1907–1912 | 174.3 | 273.7 | ..... | 215.4 | 151.1 | 173.3 | ..... | 173.1 | ..... | 373.3 |
| Commercial: | | | | | | | | | | |
| 1907–1917 | 327.6 | 713.7 | ..... | 444.5 | 234.1 | 288.1 | ..... | 295.3 | ..... | 1,114.1 |
| 1912–1917 | 61.6 | 119.8 | 61.0 | 60.1 | 41.4 | 51.0 | 47.1 | 50.3 | 131.3 | 156.5 |
| 1907–1912 | 164.6 | 270.2 | ..... | 240.0 | 136.3 | 157.0 | ..... | 162.9 | ..... | 373.3 |
| Municipal: | | | | | | | | | | |
| 1907–1917 | ..... | 1,209.7 | ..... | 385.9 | ..... | 981.8 | ..... | 1,244.4 | ..... | ..... |
| 1912–1917 | 86.7 | 153.4 | ..... | 96.9 | ..... | 97.0 | ..... | 95.8 | ..... | ..... |
| 1907–1912 | ..... | 416.8 | ..... | 146.7 | ..... | 449.2 | ..... | 586.5 | ..... | ..... |

[1] A minus sign (−) denotes decrease. Percentages are omitted when base is less than 100.

No doubt the maximum limit in size has, for practical purposes, now been reached, but the displacement of steam engines by steam turbines, which was somewhat delayed by the high costs for electrical equipment prevailing during the past few years, will undoubtedly progress rapidly in the future; and wherever practicable larger primary power units will be installed in place of the smaller in those plants which continue to generate current.

Table 37 shows in a clear way the relative importance of the changes which have taken place in steam-power development. From the percentages here given it appears that the movement away from the use of steam engines has in all cases been much more marked for commercial plants, irrespective of their size, than for municipal plants. This fact suggests that municipalities have in many cases been rather conservative in their investment policy and have used equipment which would have been scrapped by the average company, or have in other instances actually installed the discarded equipment of commercial stations. The rate of increase in number and capacity of steam turbines has been very rapid for both groups of stations, though in most cases somewhat more marked for municipal plants, due to the fact that they had little development of this nature in 1907. Those states reporting the greatest amount of steam-turbine horsepower are Pennsylvania (935,966), New York (898,848), and Illinois (843,978), in the order named. No other states approach these in capacity, though Massachusetts, Ohio, California, and Michigan report between 360,000 and 472,000 steam-turbine horsepower. Those states reporting the greatest steam-engine capacity are New York, Pennsylvania, Illinois, and Ohio, all of which have more than 100,000 horsepower. The states of Pennsylvania, New York, Illinois, Ohio, and Massachusetts report a total of 4,305,425 steam horsepower, equivalent to 51 per cent of the total capacity of steam engines and turbines in the United States.

*Internal-combustion engines.*—Internal-combustion engines include those which are operated by the combustion of oil or gas. Both natural and artificial gas are used, and sometimes gas will be produced by the electric plant by means of a gas-producer plant for the sole purpose of furnishing fuel to be used in the internal-combustion engine. This type of prime mover has for small plants and for auxiliary service numerous advantages over steam engines or steam turbines, which require a great deal of subsidiary equipment in the form of boilers, condensers, etc., and which, accordingly, take up a good deal of space and necessitate a considerable investment. Hence it is not surprising to find a rapid increase in the number of such machines, though not in horsepower capacity, during the past five years, when the costs of all kinds of equipment were much above the normal level. No doubt some plants installed gas or oil engines which would in ordinary times have preferred steam turbines. Further, it must be remembered that there has been since 1912 an extremely rapid growth of very small generating stations, in which the internal-combustion engine is the only satisfactory kind of prime mover to use.

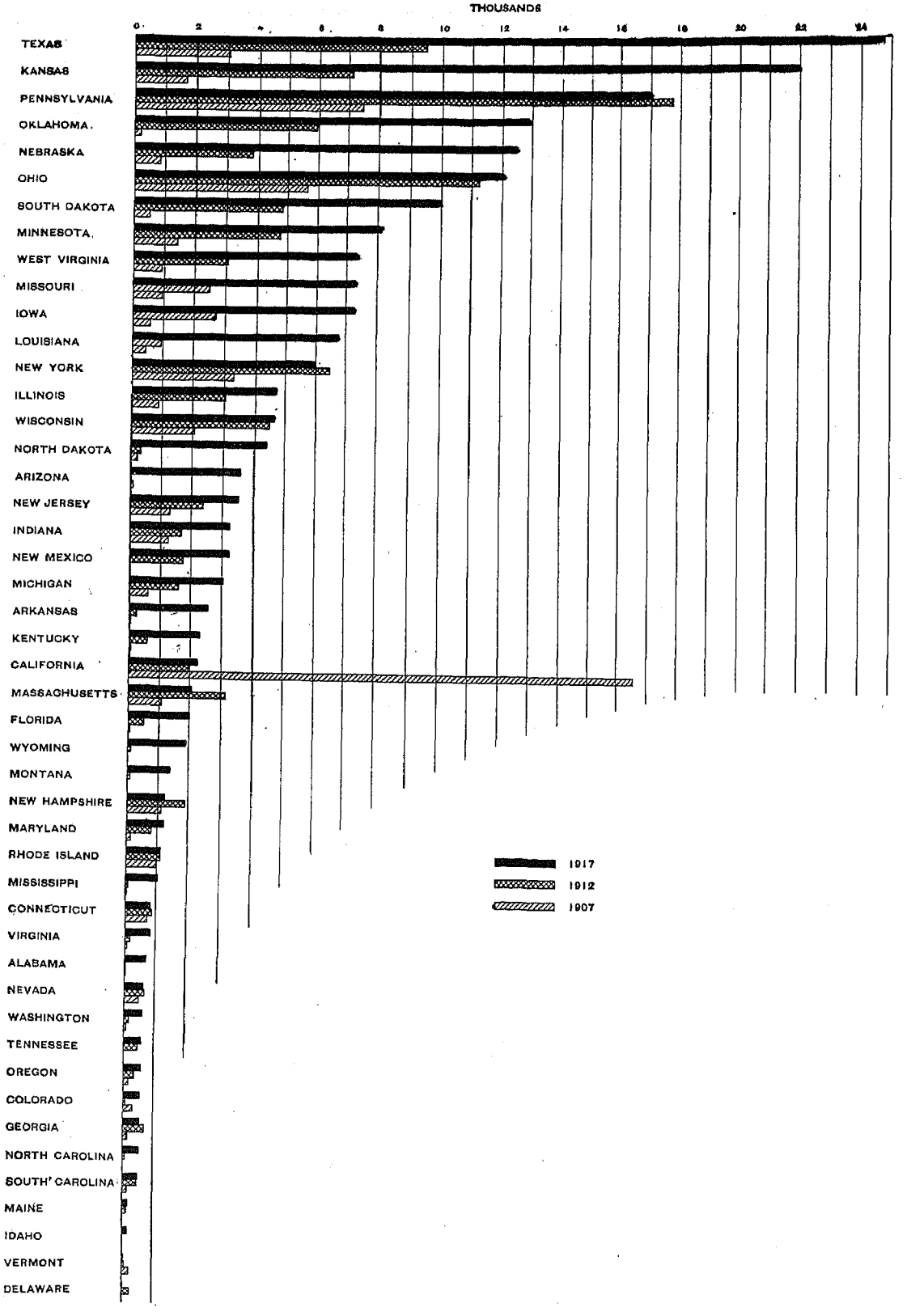
**Table 38** COMMERCIAL AND MUNICIPAL CENTRAL ELECTRIC STATIONS—INTERNAL-COMBUSTION ENGINES: 1917, 1912, AND 1907.

| CLASS OF STATIONS. | Internal-combustion engines. | | Per cent of total. | |
|---|---|---|---|---|
| | Number. | Horsepower. | Number. | Horsepower. |
| Total: | | | | |
| 1917 | 2,934 | 210,406 | 100.0 | 100.0 |
| 1912 | 1,116 | 111,035 | 100.0 | 100.0 |
| 1907 | 463 | 55,828 | 100.0 | 100.0 |
| Commercial: | | | | |
| 1917 | 1,991 | 148,574 | 67.9 | 70.6 |
| 1912 | 833 | 88,634 | 74.6 | 79.8 |
| 1907 | 385 | 49,746 | 83.2 | 89.1 |
| Municipal: | | | | |
| 1917 | 943 | 61,832 | 32.1 | 29.4 |
| 1912 | 283 | 22,401 | 25.4 | 20.2 |
| 1907 | 78 | 6,082 | 16.8 | 10.9 |
| PER CENT OF INCREASE.[1] | | | | |
| Total: | | | | |
| 1907–1917 | 533.7 | 276.9 | ..... | ..... |
| 1912–1917 | 162.9 | 89.5 | ..... | ..... |
| 1907–1912 | 141.0 | 98.9 | ..... | ..... |
| Commercial: | | | | |
| 1907–1917 | 417.1 | 198.7 | ..... | ..... |
| 1912–1917 | 139.0 | 67.6 | ..... | ..... |
| 1907–1912 | 116.4 | 78.2 | ..... | ..... |
| Municipal: | | | | |
| 1907–1917 | ..... | 916.6 | ..... | ..... |
| 1912–1917 | 233.2 | 176.0 | ..... | ..... |
| 1907–1912 | ..... | 268.3 | ..... | ..... |

[1] Percentages are omitted when base is less than 100.

After what has already been said in other connections regarding the growth in number and importance of internal-combustion engines, it is scarcely necessary to refer in more detail to the subject. Table 38 shows what the development has been, and, since all the machines are very small, no grouping according to horsepower capacity has been possible. It appears, however, that the growth in capacity of these engines has been far more rapid for municipal than for commercial plants (916.6 and 198.7 per cent, respectively) during the decade. In number also the growth for this group has been even more rapid. Compared with the total amount of primary power which is reported by municipal plants, their proportion of gas and oil engines is abnormally high, amounting in 1917 to 32.1 per cent of the number and 29.4 per cent of the horsepower capacity for both commercial and municipal plants, in spite of the fact that the capacity of the latter is only 6.6 per cent of the total. In the matter of size of units, as has already been shown, it appears that there is not much difference between the average for commercial and municipal plants (75 horsepower for the former as opposed to 66 for the latter). In 1917 all states except Utah and the District of Columbia reported internal-combustion engines. Texas led, with a capacity of 24,714 horsepower, followed by Kansas, with a horsepower of 21,965. Pennsylvania, Oklahoma, Nebraska, Ohio, and South Dakota all report internal-combustion engines with a total capacity between 10,000 and 20,000 horsepower.

DIAGRAM 6.—CENTRAL ELECTRIC STATIONS—INTERNAL-COMBUSTION ENGINES, HORSEPOWER, BY STATES: 1917, 1912, AND 1907.



*Water power.*—Water wheels and turbines continue to form a very important part of the primary power equipment of central electric stations, though they have not shown the increase in relative importance, as compared with some other types of prime movers, which might have been expected had conditions been normal during the past few years. As has already been pointed out, the initial investment in connection with hydroelectric development is very great, and it is ordinarily necessary to transmit the current produced by means of this motive power long distances over high-tension lines to the centers of industry and population, where electricity is most used. This necessitates further expenditure for overhead construction, in addition to the already high capital outlays for water-power rights, dams, etc., at the place where the generating station is located. All of these expenses are of a sort not ordinarily met with in the case of steam-power plants. Hence, during a period when the cost of material and labor is abnormally high, it would not be surprising to find a retardation of the growth of hydroelectric development in spite of the fact that, after the initial heavy investment, operating expenses are far lower than in the case of other types of electric plants. The future gains which might be secured by the conservation of fuel and the ultimate reduction of unit costs of current have during the war period been more than counterbalanced by the large capital expenditures necessary in the present in order further to develop this part of the country's natural resources. Accordingly, it is to be expected that during the latter part of the period from 1912 to 1917 there would be merely a fuller utilization of existing hydroelectric plants rather than an installation of new ones or rapid extension of service into more distant districts.

**Table 39** COMMERCIAL AND MUNICIPAL CENTRAL ELECTRIC STATIONS—WATER WHEELS AND TURBINES, BY NUMBER AND HORSEPOWER CAPACITY: 1917, 1912, AND 1907.

| CLASS OF STATIONS. | Total. | | Machines grouped according to horsepower. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 500 horsepower or under. | | Over 500 and under 2,000 horsepower. | | 2,000 and under 5,000 horsepower. | | 5,000 horsepower and over. | |
| | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. | Number. | Horsepower. |
| Total: | | | | | | | | | | |
| 1917 | 3,374 | 4,277,273 | 2,143 | 387,956 | 731 | 725,522 | 232 | 745,662 | 268 | 2,418,133 |
| 1912 | 2,939 | 2,409,231 | 2,002 | 334,737 | 637 | 591,648 | 147 | 448,760 | 153 | 1,094,086 |
| 1907 | 2,481 | 1,349,087 | 1,910 | 320,636 | 405 | 357,671 | 111 | 330,980 | 55 | 339,800 |
| Commercial: | | | | | | | | | | |
| 1917 | 3,109 | 4,076,878 | 1,922 | 350,849 | 709 | 707,234 | 226 | 730,162 | 252 | 2,288,633 |
| 1912 | 2,670 | 2,338,970 | 1,804 | 299,616 | 575 | 551,308 | 144 | 441,960 | 147 | 1,046,086 |
| 1907 | 2,328 | 1,318,740 | 1,761 | 296,689 | 403 | 355,671 | 109 | 326,580 | 55 | 339,800 |
| Municipal: | | | | | | | | | | |
| 1917 | 265 | 200,395 | 221 | 37,107 | 22 | 18,288 | 6 | 15,500 | 16 | 129,500 |
| 1912 | 269 | 130,261 | 198 | 35,121 | 62 | 40,340 | 3 | 6,800 | 6 | 48,000 |
| 1907 | 153 | 30,347 | 149 | 23,947 | 2 | 2,000 | 2 | 4,400 | ..... | ..... |
| | PER CENT OF INCREASE.[1] | | | | | | | | | |
| Total: | | | | | | | | | | |
| 1907–1917 | 36.0 | 217.0 | 12.2 | 21.0 | 80.5 | 102.8 | 109.0 | 125.3 | ..... | 611.6 |
| 1912–1917 | 14.8 | 73.2 | 7.0 | 15.9 | 14.8 | 22.6 | 57.8 | 66.2 | 75.2 | 121.0 |
| 1907–1912 | 18.5 | 83.0 | 4.8 | 4.4 | 57.3 | 65.4 | 32.4 | 35.6 | ..... | 222.0 |
| Commercial: | | | | | | | | | | |
| 1907–1917 | 33.5 | 209.1 | 9.1 | 18.2 | 75.9 | 98.8 | 107.3 | 123.6 | ..... | 573.5 |
| 1912–1917 | 16.4 | 74.3 | 6.5 | 17.1 | 23.3 | 28.3 | 56.9 | 65.2 | 71.4 | 118.8 |
| 1907–1912 | 14.7 | 77.4 | 2.4 | 1.0 | 42.7 | 55.0 | 32.1 | 35.3 | ..... | 207.9 |
| Municipal: | | | | | | | | | | |
| 1907–1917 | 73.2 | 560.3 | 48.3 | 55.0 | ..... | 814.4 | ..... | 252.3 | ..... | ..... |
| 1912–1917 | −1.5 | 53.8 | 11.6 | 5.6 | ..... | −54.7 | ..... | 127.9 | ..... | 169.8 |
| 1907–1912 | 75.8 | 329.2 | 32.9 | 46.7 | ..... | 1,917.0 | ..... | 54.5 | ..... | ..... |
| | PER CENT DISTRIBUTION. | | | | | | | | | |
| Total: | | | | | | | | | | |
| 1917 | 100.0 | 100.0 | 63.5 | 9.1 | 21.7 | 17.0 | 6.9 | 17.4 | 7.9 | 56.5 |
| 1912 | 100.0 | 100.0 | 68.1 | 13.6 | 21.7 | 24.0 | 5.0 | 18.2 | 5.2 | 44.3 |
| 1907 | 100.0 | 100.0 | 77.0 | 23.8 | 16.3 | 26.5 | 4.5 | 24.5 | 2.2 | 25.2 |
| Commercial: | | | | | | | | | | |
| 1917 | 100.0 | 100.0 | 61.8 | 8.6 | 22.8 | 17.3 | 7.3 | 17.9 | 8.1 | 56.1 |
| 1912 | 100.0 | 100.0 | 67.6 | 12.8 | 21.5 | 23.6 | 5.4 | 18.9 | 5.5 | 44.7 |
| 1907 | 100.0 | 100.0 | 75.6 | 22.5 | 17.3 | 27.0 | 4.7 | 24.8 | 2.4 | 25.8 |
| Municipal: | | | | | | | | | | |
| 1917 | 100.0 | 100.0 | 83.4 | 18.5 | 8.3 | 9.1 | 2.3 | 7.7 | 6.0 | 64.6 |
| 1912 | 100.0 | 100.0 | 73.6 | 27.0 | 23.0 | 31.0 | 1.2 | 5.2 | 2.2 | 36.8 |
| 1907 | 100.0 | 100.0 | 97.4 | 78.9 | 1.4 | 6.6 | 1.3 | 14.5 | ..... | ..... |

[1] A minus sign (−) denotes decrease. Percentages are omitted when base is less than 100.

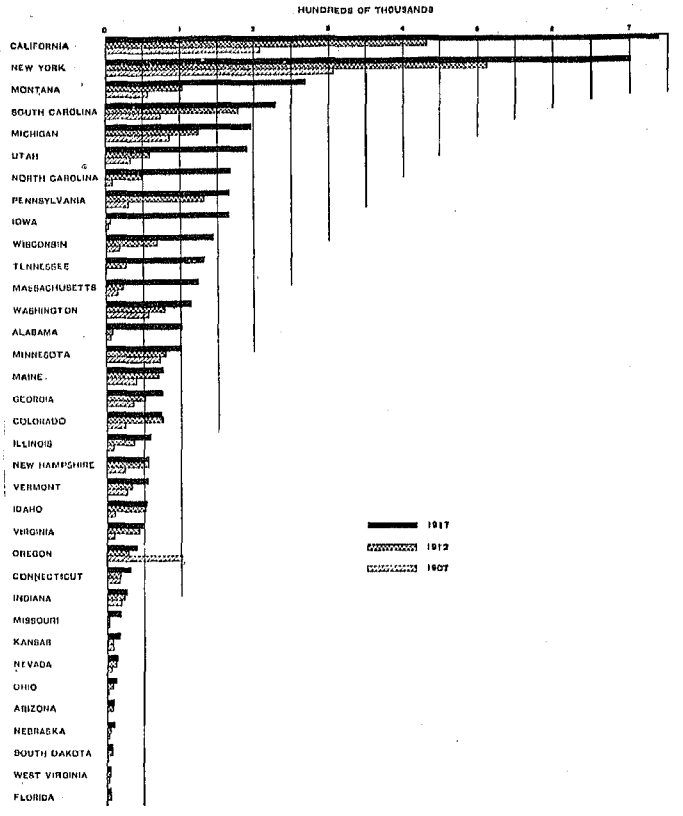
As will be seen from Table 39, at each of the three censuses the bulk of the hydroelectric power, 95.3, 94.7, and 97.8 per cent, respectively, was reported for commercial stations. A further examination of the table shows that during the past five years there has been a more rapid increase in horsepower of water

wheels and turbines for commercial than for municipal stations (74.3 per cent as opposed to 53.8 per cent), though for the decade the increase has been much more rapid for municipal plants, which in 1907 used very little of this kind of primary power. In the different groupings according to horsepower capacity it is interesting to find that for both classes of stations those machines of less than 500 horsepower are most numerous, though in the case of commercial plants they rank lowest in total capacity (8.6 per cent), while in municipal plants such units rank second (18.5 per cent). In both classes of stations, also, the largest proportion of horsepower is found in that group of machines having 5,000 horsepower and over. The per cent of increase in horsepower capacity during the decade has for commercial plants been most marked, 573.5 per cent, in the highest group. For both groups, also, during the past five years the most rapid increase in capacity has taken place in those machines having more than 5,000 horsepower. The rate of increase in the capacity of the smallest group of units, while not rapid in either case, was somewhat more marked for commercial plants, 17.1 per cent, as contrasted with 5.6 per cent for municipal plants. It is rather surprising to find that in the group between 500 and 2,000 horsepower municipal plants have shown since 1912 a decrease of 54.7 per cent in capacity, whereas commercial plants report a gain of 28.3 per cent. For those water wheels and turbines having a capacity of 5,000 horsepower or greater the average capacity is 9,023 horsepower as opposed to 12,981 horsepower for steam turbines in the same group.

The statistics for water-power development in connection with central electric light and power stations give rise to certain anomalies which did not occur in the data covering the types of prime movers already discussed. Owing to the fact that some important hydroelectric plants have numerous generating stations frequently widely scattered and even located in different states, though all serving as part of the same distributing system, it is difficult to present absolutely accurate figures as to the number and capacity of water wheels and turbines in the different states. There were, in 1917, 1,079 different stations which reported some water power and 259 which had water wheels and turbines, totaling 1,000 horsepower or more. Many stations, of course, report other types of primary power machines in addition, which are sometimes used only as auxiliaries when water power is insufficient, though in other instances the different types are constantly used. It is to be expected, however, that whenever possible the water power will be used for generating current in order to save the cost of fuel. Finally, there are 548 plants or stations which use water power only, as shown in Table 35.

DIAGRAM 7.—WATER POWER, BY STATES: 1917, 1912, AND 1907.

[States with less than 5,000 horsepower in 1917 are omitted.]




The map in Chapter III indicates those sections of the country in which large hydroelectric developments are found. So far as the total capacity of water wheels and turbines for the different states is concerned, it appears that California leads, with 738,977 horsepower. This state is closely followed by New York, with 701,948 horsepower; Montana ranks third, with 268,917, and South Carolina fourth, with 230,099. No other states report as much as 200,000 horsepower in water wheels and turbines, though there are 11 which have between 100,000 and 200,000 horsepower—Michigan, Utah, North Carolina, Pennsylvania, Iowa, Wisconsin, Tennessee, Massachusetts, Washington, Alabama, and Minnesota, in the order named. Five states—California, New York, Montana, South Carolina, and Michigan—report a total of 2,138,156 water horsepower, or almost 50 per cent of the total for the United States. In 1912 there were only 6 states reporting more than 100,000 water horsepower, as opposed to 15 in 1917.